PC-403 — VOLUME III OF III PIONEER VENUS MULTIPROBE SPACECRAFT MISSION OPERATIONAL CHARACTERISTICS DOCUMENT

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HUGHES AIRCRAFT COMPANY
SPACE AND COMMUNICATIONS GROUP
EL SEGUNDO, CALIFORNIA

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4.3 SPACECRAFT OPERATIONS

Descriptions of Primary and Backup Operational Modes and Operational Limitations for Maneuvers, Roll Reference Transfer, Attitude Determination, Spacecraft Power Discipline and Spacecraft Thermal Discipline, are described below.

4.3.1 Maneuvers. A General Description; Common Maneuvers Strategy and Tactics; Strategy and Tactics unique to each of precession, _V, and spin rate maneuvers; and typical command sequences with corresponding telemetry verification for each of these three types of maneuvers are described ahead.

4.3.1.1 General Description. Spacecraft maneuvers include all commanded changes in spacecraft attitude (via precession), or velocity (via translation), or spin rate (change in angular momentum). Maneuvers are performed to establish and maintain attitude and spin rate during cruise, to correct errors in velocity (trajectory correction maneuvers), to adjust spin rate and attitude before and after the Large Probe is released, before and after Small Probes release, and before Bus entry.

Execution of any one maneuver will result in a deficiency or excess in the magnitude of the desired maneuver. This is due primarily to impulse uncertainty, and is caused by variations in thruster(s) performance. Any one maneuver will result also in small changes as if each of the remaining two types of maneuvers had been executed as well. These cross-coupling errors, as they are called, are caused not only by imperfect mechanical alignment and unbalance of the thrusters, but also by imperfect timing in thruster(s) burn; and will vary as mass properties change due to depletion of liquid propellant and release of the probes. Another unwanted effect, nutation will also result; nutation is the inertial coning motion of the spin axis about the angular momentum vector.

Strategy and tactics common to the three types of maneuvers are described in Sections 4.3.1.2 and 4.3.1.3, respectively. The approach to maneuvers, and the significance of impulse uncertainty, coupling errors and nutation are described in these sections.

Each of the three types of maneuvers, including its unique strategy, tactics, characteristics, and typical command sequence, are detailed in Sections 4.3.1.4 through 4.3.1.6.

4.3.1.2 Common Strategy. Strategy is the basic plan, independent of the spacecraft design and the point in the mission. Strategy common to the three types of maneuvers consists essentially of (1) defining the pre-maneuver conditions of spacecraft mechanics and propulsion performance parameters, the desired post-maneuver conditions, and the best way to accomplish the post-maneuver conditions; (2) doing the maneuver, and (3) verifying the adequacy of the result.

Specific strategy begins with determining the pre-maneuver spacecraft attitude, velocity, position, spin rate, and nutation (if any is present). Determining velocity and position are relatively time-consuming for any spacecraft design. The degree of accuracy to which each of these five characteristics are to be determined varies according to the maneuver type and required magnitude. It is sometimes constrained by lack of available time for determination, which in turn, may be due to spacecraft thermal, power, or communications link performance constraints.

The pre-maneuver propulsion performance parameters are updated next, using pre-launch measured values and any in-flight calibration data that may be available. These are the impulse characteristics of each thruster, and the spacecraft mass properties. This information is used to define, via appropriate offline software, maneuver parameters, i.e., the burn duration (continuous or number of pulses), jet start angle (pulse maneuvers), the expected cross-coupling

and the expected nutation associated with any required post-maneuver conditions.

Maneuver strategy will emphasize: (1) Minimum fuel usage, (2) minimum disturbance to the communication links, power profile, and thermal profile, (3) maneuver accuracy and (4) simple and safe operation, including performance of the maneuver event in the shortest amount of time. The time element becomes increasingly significant as the one-way communications time between earth and spacecraft increases (one way communications time when the Multiprobe spacecraft is near Venus is approximately three minutes. All of the ideal goals are not attainable simultaneously. Their relative priority of importance depends in part on the point in the mission, the condition of the spacecraft, and the mission impact resulting from each ideal goal that is compromised or omitted.

The maneuver is then executed, and the result is assessed to determine if it is acceptably close to the required results. Post-maneuver attitude, velocity, position, spin rate, and nutation should all be determined for the first usage of each thruster to refine the models of mass properties and thruster impulse until they are sufficiently accurate. Subsequent post-maneuvers assessments need then be only partial. If the result is inadequate, then the cycle should be repeated using revised performance parameters.

4.3.1.3 Common Tactics. Tactics consist of the specific implementation of the strategy, unique to the spacecraft design and to the point in the mission.

Successful completion of a maneuver requires the use of all the Multiprobe's subsystems. The controls subsystem supplies the attitude measurements and thruster control signals; the propulsion subsystem supplies the impulse required to move the spacecraft; the command and data handling subsystems process the commands necessary to perform the maneuver and the telemetry conditioning necessary to verify the maneuver; the communications subsystem receives

the commands, transmits the telemetry and indicates certain maneuver performance by doppler shift and change in ground-received signal strength; and the power subsystem supplies the electrical power necessary to operate all of the required units.

Tactics for the Multiprobe begin with determining the pre-maneuver spacecraft attitude, spin rate, and nutation (if any is present). Attitude and spin rate determinations are described in Sections 3.3.3.6, 3.3.3.7 and 4.3.2. The preferred method for determining attitude, via use of sun-to-star(s) time measurements, is functionally independent of the point in the mission, but the choice of star(s) varies during the mission as described in Sections 3.0 and 4.3.2. The preferred method for determining the spin rate is essentially independent of the point in the mission, as long as the sun is within the FOV of a sun sensor.

Nutation will have reduced to negligible levels if the previous maneuver had occurred many hours ago. It should have been measured immediately after the previous maneuver to aid in updating mass properties and thrust level for the forthcoming maneuver. (The Nutation angle (half-cone angle between the spacecraft spin axis and the angular momentum vector about which the spin axis is coning) should be <1° in magnitude before beginning any maneuver). Telemetered $\psi - \psi_2$ time delay (ATTH1Z and ATTH2Z) will vary approximately sinusoidally when nutation is present. The equivalent spin angle delay variation can be converted to the sun aspect angle variation by use of the appropriate equation shown in Figures 3.3.2.1-1 or 3.3.2.1-2. Resolution in sun L.O.S. (Line-of-Sight) angle measurement varies with spin rate and offset from the boresight axis of the sun sensor. For the nominal cruise attitude and spin rate of 15 rpm, the telemetered resolution of ±0.25 millisecond time delay translates into a sun L.O.S. resolution of ±0.0230°.

Determination of pre-maneuver velocity and position is done conventionally via the onboard phase-lockable S-band system and doppler measurements.

Updating of mass properties and impulse for accurate prediction of the forthcoming maneuver is important due to the propulsion system design. The spacecraft uses an unregulated mass-expulsion propulsion system. Steady depletion of fuel results in decreasing pressure and corresponding thrust level for the thrusters (A "blowdown" system - refer to Figure 3.4.2.1-3 through 3.4.2.1-5, and Figure 3.4.2.3-1).

The arrangement of the six thrusters on the Multiprobe Spacecraft is shown pictorially in Figures 3.4.1-3 and 3.4.1-4. Table 3.4.1-2 further specifies thrusters geometry. Two of the six thrusters are aligned parallel to and offset from the spin axis. These axial thrusters, one called forward and the other called aft, are used for precession and velocity change maneuvers. The four remaining thrusters are aligned offset from and approximately perpendicular to the spin axis. These four radial thrusters are divided into two pairs; the plane of the thrust vectors of each pair is canted relative to the plane perpendicular to the spin axis in order to pass through the center of mass during a particular phase of the mission. In particular, radial thrusters R3 and R4 are canted through the center of mass at the time of the first trajectory correction maneuver and radial thrusters R1 and R2 are canted through the Multiprobe center of mass after Large Probe separation. Each thruster can be operated in either the continuous or pulse mode. In the pulse mode, the pulse on time can be either 128 milliseconds or 512 milliseconds. Table 4.3.1.3-1 details the types of maneuvers that can be performed with various thruster combinations.

The essential significance of each mass property parameter and other pertinent parameters for each of the three types of maneuvers is shown in Table 4.3.1.3-2. (The relationships are detailed in

later sections). Nominal mass parameters are listed in Table 3.1.2-3. Tolerances on these and thruster related parameters are used to predict the expected crosscoupling errors associated with each candidate set of thrusters for the forthcoming maneuver.

There are a large number of possible thruster and thruster operating mode combinations. Not all of the possible combinations are practical, and certain combinations are more advantageous than others for some maneuvers. There are four criteria used for selecting the thruster or thrusters and operating mode used in a particular maneuver. These are efficiency, granularity, maneuver duration and the disturbances caused by the maneuver. Efficiency is defined as the size of maneuver that can be performed per unit of propellant; it is affected by spacecraft spin rate, mass, moments of inertia, propulsion subsystem pressure, cant angle of the radial thrusters and pulse width in the pulse mode. Since several of these parameters change during the mission, the efficiency of a given maneuver changes throughout the mission. Granularity is defined as the minimum maneuver that can be performed by one pulse or one second of continuous burn. Granularity is affected by the same parameters as efficiency and thus, also changes throughout the mission. Maneuver duration is affected by the size of the maneuver, the granularity of the maneuver, the number of thrusters used, and the thruster operating mode used. The disturbances caused during a maneuver include uncertainties in the planned maneuver, nutation and cross-coupling of other maneuver types such as precession and spin speed changes during velocity change maneuvers. Disturbances are caused by thrust misalignments, cant angles of the radial thrusters and uncertainties in spacecraft mass properties and thruster performance. Table 4.3.1.3-3 lists the thrusters and operating modes selected for the Multiprobe mission and includes the efficiency and granularity of each maneuver. The rationale for these selections is discussed in the following paragraphs.

The basic method for performing an axial ΔV maneuver is to use a single axial thruster in the continuous mode. Because the axial thrusters are offset from the spin axis, the use of a single axial thruster causes precession and nutation in addition to the desired axial ΔV. Coupled radial ΔV and spin speed changes are caused by misalignments and principal axis tilt.

The axial ΔV granularity is greater after Large Probe separation because the reduction in mass resulting from Large Probe separation is not offset by the reduction in thrust due to pressurant blowdown. The efficiency of axial ΔV maneuvers increases after Large Probe Separation because the reduction in spacecraft mass is greater than the reduction in specific impulse due to propellant blowdown.

An alternate method for performing an axial ΔV maneuver (pulsing a single axial jet twice per spin period) can be used to minimize attitude perturbations during axial ΔV trims. Relative to the nominal continuous mode, this 180° bang-bang mode increases maneuver duration by a factor of ≈ 4 and requires 10% more propellant to execute the same maneuver.

A radial ΔV maneuver, i.e., the radial velocity component of a total ΔV maneuver, can only be performed in a pulse mode. The pair of radial thrusters canted closest to the center of mass at the time of the maneuver (R3 and R4 prior to Large Probe separation, and R1 and R2 after Large Probe Separation) is used in order to minimize precession. Radial ΔV maneuvers tend to be lengthy since only one pulse pair can be fired per spin period. Thus, the 512 millisecond pulse width is used to minimize the duration of the maneuver. Radial ΔV maneuvers are less efficient than comparable axial ΔV maneuvers because of the lower thruster I_{sp} in the pulse mode, the trigonometric loss due to the angle swept during the pulse on time and the trigonometric loss due to the cant angle of the radial thrusters. Because of the cant angle, there is an axial velocity change whenever a radial ΔV maneuver is

performed. In addition, if the thrust vector plane does not pass through the spacecraft center of mass, precession will occur. Uncertainties in radial ΔV in the desired and transverse direction, axial ΔV, spin change, precession and nutation all occur due to misalignments and thruster mismatches and performance uncertainties.

Spin speed changes can be accomplished by firing a diagonally opposite pair of radial thrusters in the continuous mode or firing a single radial thruster in the continuous mode. The normal method is to use the diagonally opposite pair. This method is efficient and minimizes attitude disturbances. The single radial thruster fired in the continuous mode is used in failure mode situations. This method improves granularity but increases attitude disturbances. Spin thrusters can be pulsed at twice spin period to improve granularity and minimize attitude disturbances during spin speed trims; this mode requires $\approx$10 percent more propellant to execute the same maneuver.

Spin speed granularity is about the same for both the cruise and post-Large Probe separation configurations because the reduction in thrust due to pressurant blowdown is offset by the decrease in spacecraft spin moment of inertia after Large Probe separation. Spin maneuvers are slightly more efficient after Large Probe separation because the reduced spin moment of inertia more than offsets the degradation in specific impulse.

Attitude precession maneuvers are always performed in the pulse mode using one of three methods: The Forward and Aft axial thrusters as a couple, a single axial thruster or the radial thruster pair that is not aligned through the spacecraft center of mass at the time of the maneuver. The use of the axial couple is efficient and minimizes velocity disturbances. The single axial thruster precession maneuver has the same efficiency as the axial couple method, but there is an inherent axial velocity change.

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The granularity of the single thruster maneuver is improved by a factor of two

Attitude precession granularity is smaller after Large Probe separation because of the large increase in spacecraft spin rate. Precession efficiency is lower, however, because of the higher angular momentum state.

Precession maneuvers can also be performed using the radial thruster pair whose thrust vector plane is offset from the center of mass. This type of precession maneuver offers the smallest granularity but is only 16% as efficient as a precession maneuver performed with the axial thrusters. There is also a radial velocity change inherent in this maneuver. In addition to the cross-coupling errors mentioned above, each of these precession maneuvers causes attitude disturbances and velocity changes due to misalignments and thruster performance uncertainties.

A set of thrusters and its operating mode have been selected for each of nominal mission maneuvers. The expected performance for each mission maneuver is shown in Table 4.1.1.4-1.

The increasing one-way communications link time delay cited earlier is an inducement to use the onboard command memories for operational safety, wherever timing in execution of commands is critical. Spacecraft commanding should be done in real time wherever possible, but the onboard command memories should be used to execute backup commands that will return the spacecraft to a safe state. Detailed descriptions of how to use the command memories are provided in Section 3.6.

Detailed instructions and usage restrictions for structuring the ADP configure quantitative command for measurements and jets control during a maneuver event ((ATQØ1 or ATQØA) through (ATQ12 or ATQØL), respectively), are contained in Sections 3.3.3.5 and 3.3.3.11, respectively.

The maneuver is then executed, and the result is assessed for accuracy. Any thruster maneuver also offers the opportunity for post-maneuver resolution between thruster tolerances and observed cross-coupling errors.

4.3.1.4 Precession Maneuver

4.3.1.4.1 Precession Maneuver Strategy. The initial and final (desired) spin axis orientations are each specified by two angles referenced to a convenient inertial frame. The spacecraft is precessed from the initial to the final orientation by applying an inertially referenced moment normal to the spin axis. This precession moment is supplied by pulsing axial (or radial) jets that are offset from the spacecraft center of mass; to obtain the proper inertial direction, these jets are fired at a fixed lag angle from an inertial reference (sun or star).

A convenient inertial frame for a reorientation maneuver starts with the spacecraft at the origin and with one axis directed towards the sun (primary inertial reference with stars as backup). The second axis is orthogonal to the sunline and in the plane defined by the sunline and north ecliptic pole. Note that the sunline and north ecliptic pole are not typically orthogonal because the spacecraft flies outside of the ecliptic plane. The third axis completes the triad. The two angles that specify the orientation of the spin axis are shown in Figure 4.3.1.4.1-1: ϕ being the angle between the sunline and the spin axis, and θ being the dihedral angle between the plane defined by the sunline/north ecliptic pole and the sunline/spin-axis plane (right handed rule). Relative to the unit sphere shown in Figure 4.3.1.4.1-1 with the sun as a pole, the tip of the unit spin axis vector is at co-latitude ϕ and on meridian (or at longitude) θ.

An arbitrary infinitesimal precession of the spin axis is shown schematically in Figure 4.3.1.4.1-2; dP is the magnitude of the precession and the direction is given by the angle ψ. ψ is the

angle of rotation about the spin axis measured, as shown in Figure 4.3.1.4.1-2, from the sunline/spin axis plane to the direction of precession. ψ, called phase angle hereafter, differs by a ±90° from the jet-lag angle since jet torque is orthogonal to jet thrust. In practice, the jet-lag angle is measured from the sun pulse; and this angle, and accordingly, ψ, are held constant during an ideal precession maneuver. On the unit sphere (shown in Figure 4.3.1.4.1-1), the tip of the unit spin axis vector describes a rhumb line, i.e., crosses successive meridians at the same angle; in the Mercator projection, the rhumb line appears as a straight line.

The basic kinematical equations follow from Figure 4.3.1.4.1-2:

$$\Delta\theta = \theta_F - \theta_I = \tan\psi \;\; \ln\left[\frac{\tan\left(\frac{\phi_F}{2}\right)}{\tan\left(\frac{\phi_I}{2}\right)}\right] \qquad (1)$$

$$\Delta\phi = \phi_F - \phi_I = -P\cos\psi \qquad (2)$$

where the subscripts I and F refer to initial and final orientations, respectively. For given initial and final orientations, the phase angle, ψ, is obtained from Equation (1) and the total required precession angle, P, from Equation (2).

4.3.1.4.2 Precession Maneuver Tactics

4.3.1.4.2.1 Implementation. The actual precession maneuver is conducted by pulsing axial (or radial) jets at a fixed lag angle (from the sunline) as determined from ψ (Equation (1)). An uncertainty in this lag angle, equivalent to $\delta\psi$, will obviously affect the final orientation of the spacecraft. Each pulse precesses the spacecraft through a nominal small angle. P, obtained from Equation (2), determines the number of pulses and an uncertainty in the precession increment leads

to an uncertainty in the actual P, denoted by δP, which, in turn, leads to uncertainties in the final orientation of the spacecraft.

In addition to the two uncertainties -- $\delta\psi$ and δP -- there are also two uncertainties in the initial orientation of the spacecraft. The initial uncertainty in co-latitude, ϕ, will be denoted by $\delta\phi_I$ and will be called an in-plane uncertainty -- in-plane referring to the sunline/spin-axis plane. This uncertainty is due to sun sensor measurement errors. The second initial attitude uncertainty will be defined as an uncertainty normal to this plane, will be denoted by ϵ_I, and will be called an out-of-plane uncertainty. This uncertainty is due to star sensor measurement errors.

Uncertainties in the final orientation of the spacecraft will also be defined as the in- and out-of-plane uncertainties -- denoted by $\delta\phi_F$ and ϵ_F, respectively; in-plane now refers to the final sunline/spin-axis plane. In particular,

$$\delta\phi_F = e_1\ (\delta\phi_I) + e_2\ (\epsilon_I) + e_3\ (\delta\psi) + e_4\ (\delta P)$$

$$\epsilon_F = f_1\ \delta\phi_I + f_2\ (\epsilon_I) + f_3\ (\delta\psi) + f_4\ (\delta P)$$

where the e's and f's are error coefficients (or partial derivatives) defined in Table 4.3.1.4.2-1. Note that final values of the output uncertainties in each plane are obtained by root-sum-squaring the corresponding contributions shown in the equations above. The total attitude error is given by

$$\sqrt{(\delta\phi_F)^2 + (\epsilon_F)^2}.$$

To obtain the values to achieve an open-loop precession along a rhumb line path, a number of steps must be taken:

(a) The values of longitude (θ_I, θ_F) and co-latitude (β_I, β_F), which describe the initial and final orientation, are used to obtain the rhumb line parameters, ϕ and P. These describe the angle to the sun, and the length of the ideal rhumb line. The logic for determining the correct phase angle ϕ, and quadrant Q is defined in Figure 4.3.1.4.2-1.

(b) The propulsion performance characteristics (calibrated impulse and impulse centroid location) are then used to define the required number of pulses to achieve P and the appropriate jet start angle corresponding to ϕ.

(c) An estimate of the total attitude error resulting from the maneuver is made from known tolerances to insure that the range of actual attitudes achieved is acceptable. In addition, various attitudes along the rhumb line path are examined for compatibility with any power, thermal and communications constraints.

(d) The required set of spacecraft commands is constructed, transmitted and verified prior to maneuver execution.

The process is best illustrated by a representative example, the nominal/mission scheduled reor to the Small Probe release attitude. Figure 4.3.1.4.2-2 illustrates the relevant geometry as well as celestial latitude and longitude of the sunline, initial attitude and final attitude. β_i, β_f and $\Delta\theta$ are first defined as follows: From Figure 4.3.1.4.2-2, the initial (β_i) and final (β_f) sun angles are determined to be:

$$\cos \beta_i = \cos(-1.8) \cos(15) \cos(244-195) + \sin(-1.8) \sin(15) \Rightarrow \beta_i = 51.3^\circ$$

$$\cos \beta_f = \cos(-1.8) \cos(15.8) \cos(244-234.5) + \sin(-1.8) \sin(-15.8) \Rightarrow \beta_f = 16.8^\circ$$

The great circle precession, ΔP, is given by:

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$$\cos \Delta P = \cos(15) \cos(-15.8) \cos(234.5-295) + \sin(15) \sin(-15.8) \Rightarrow \Delta P = 49.7^\circ$$

The rotation of the spin axis/sunline plane, $\Delta\theta$, is obtained from the law of cosines,

$$\cos \Delta\theta) = \frac{\cos 49.7^\circ - \cos 51.3^\circ \cos 16.8^\circ}{\sin 51.3^\circ \sin 16.8^\circ}$$

$$\Rightarrow \Delta\theta = 77.7^\circ$$

The rhumb line Equations ((1) and (2) of Section 4.3.1.4.1) can now be used to solve for the nominal rhumb line precession, P_R, and jet start angle ϕ:

$$\tan \phi = \frac{\Delta\theta}{\ln\left[\frac{\tan \beta_{f/2}}{\tan \beta_{i/2}}\right]} = \frac{1.356}{-1.1756} = \phi = 310.9^\circ$$

$$P = \frac{-(\beta_f - \beta_i)}{\cos \phi} \Rightarrow P_R = 52.5^\circ$$

Using the nominal parameters under discussion, the in-plane and out-of-plane errors are defined from Table 4.3.1.4.2-1 to be

$$\delta\beta_f^2 = \delta\beta_i^2 + (.48)\ (\phi^2 + (.43)\ \delta P^2$$

$$\delta\epsilon_f^2 = (.53)\ (\delta\beta_i^2) + (.14)\ (\delta E_i^2) + (.0001)\ \delta\phi^2 + (.57)\ (\delta P^2)$$

where initial and final errors are measured in degrees. Assuming initial in plane and out of plane errors of $\approx 0.5^\circ$, a phase angle error of $\approx 3^\circ$ and a 3% impulse error (i.e., $\delta P = 1.6^\circ$) results in a final in-plane error of 2.4° and final out of plane error of 1.3°. The total attitude error after the maneuver is then 2.7°; the maneuver

adds ≈2° to the initial total attitude uncertainty of 0.7°.

Impulse characteristics of the thrusters are used to define the required number of pulses (see Section 4.3.1.4.2.2). Impulse centroid characteristics and thruster/sun sensor geometry are employed to convert from the phase angle, ϕ, to an appropriate jet start angle.

4.3.1.4.2.2 Precession Dynamics. Precession of a spinning spacecraft such as the Multiprobe is accomplished by firing gas jets that generate an applied torque normal to the spin axis. Successive torque pulses will cause the angular momentum vector to precess and will induce a coning motion of the spin axis about the angular momentum vector.

The angular momentum step size dP is given by the following equation (also shown on Figure 4.3.1.4.2.3-1):

$$dP = \left(\frac{K \cdot P \cdot R \cdot T}{H_S}\right)\left(\frac{\sin \theta/2}{\theta/2}\right)$$

where

K = Number of Axial Jets fired.

P = Axial jet thrust (lb.)

R = Radius to axial jets (feet)

T = Pulse burn duration (seconds)

H_S = Spinning angular momentum [(slug-ft^2) x (rad/sec)]

= $I_{ZT}\omega_{OT}$ = Total spinning Inertia times the total spacecraft spin rate for a spinning configuration

θ = Burn angle (degrees) = $w_{OT}T$

$$\left(\frac{\sin(\theta/2)}{\theta/2}\right) = \text{efficiency of the thrusters.}$$

The command resolutions for a precession, i.e., the angular step size in degrees per pulse (128 ms) are shown in Table 4.3.1.3-3, for several thruster combinations and the two basic phases in the mission.

4.3.1.4.2.3 Precession Maneuver Parameters and Algorithms. Maneuver parameters that are significant for a precession are shown in Table 4.3.1.3-2. Their first order effect and algorithms relationship are shown in Figure 4.3.1.4.2.3-1.

4.3.1.4.2.4 Restrictions. Restrictions unique to a precession maneuver include: 1) a time limitation, depending on sun L.O.S. and solar intensity, according to Figure 3.2.3-1, to avoid excessive thermal imbalance, 2) sun L.O.S. restriction to insure power balance. This also varies with solar intensity, batteries level of charge, and spacecraft load level (see Sections 3.8.3 and 4.3.5), 3) sun L.O.S. restriction on usage of any one of the three sun sensors as the SRR. If each of the initial and final spin axis angles w.r.t. the ecliptic normal is <30°, the mid-range sun sensor should be used. If the final spin axis angle is ≥30°, then the appropriate extended sun sensor should be selected prior to the start of the precession. 4) Earth l.o.s. restrictions on usage of any one of the three available antennas. Each antenna's effective field-of-view is described in Sections 2.3.2.1 and 2.3.2.2. Switchover to transmitter Hi power, then to the highest bit rate usable on the most effective omni, (followed by switchover to that omni if that omni is not already being used), prior to the start of the precession is the most-likely required action for most precessions, and 5) the nutation angle should be <1° before beginning any maneuver.

4.3.1.4.3 Typical Command Sequence and Telemetry Verification. Initial and changed spacecraft configurations for a typical precession maneuver are shown in Table 4.3.1.4.3-1. The full description of the initial configuration is shown in the first column ("Assumed Steady State" column). Only the changes in configuration, from the preceding column, are shown in subsequent columns.

A detailed typical command sequence for a precession, with associated telemetry verification, for an in-transit precession from ecliptic-normal attitude, is shown in Table 4.3.1.4.3-2.

4.3.1.5 Trajectory Modification Maneuvers (ΔV)

4.3.1.5.1 ΔV Maneuver Strategy. A ΔV maneuver accomplished in the cruise mode, does not significantly disturb the prevailing communications links, thermal profile, and power profile. By resolving the required velocity change into velocity components that are parallel to an quasi-orthogonal set of spacecraft thrusters (vector mode), these disturbances are avoided. The operational complexity of pre- and post-maneuver precessions required for a ΔV maneuver with axial jets only (axial mode) or radial jets only (radial mode) can be avoided by executing two successive, but operationally simpler, maneuvers.

However, the weight penalty associated with use of the vector mode for the first midcourse ($\Delta V \leq 12$ m/sec) may be significant, so that use of the axial or radial modes for this maneuver would be more prudent. The magnitude of the multiprobe first midcourse and the large cant angles of the multiprobe radial jets necessitate the trade. Figure 4.3.1.5.1-1 illustrates the weight penalties for vector mode vs. axial mode and vector mode vs. radial mode as a function of the angle between the spin axis cruise attitude (south ecliptic pole) and the ΔV direction. The required velocity increment is assumed to lie in a plane orthogonal to the sunline, so that the spacecraft sun angle is always ≈ 90 degrees and no

thermal or power considerations constrain the axial or radial modes. The vector mode is observed to have a significant weight penalty, ≈ 9 lbs, when the required ΔV direction is ≈ 30 degrees above the ecliptic plane; such a direction demands axial jet thrust to cancel the axial ΔV component of the canted radial jets and achieve the proper sense for the total velocity increment. Since the axial mode is operationally simpler than the radial mode and usually more efficient, the axial mode would be preferred for such large ΔV maneuvers with troublesome directions in the north ecliptic hemisphere.

When the required velocity increment is assumed to lie in a plane containing the cruise attitude and the sunline, the spacecraft sun angle will vary and thermal/power constraints do constrain the use of the axial and radial modes. At the time of the first midcourse, spacecraft sun angle is constrained to be greater than 65 degrees and less than 120 degrees if a specific attitude is to be maintained for at least 4 hours. This constraint permits use of the radial mode only when the ΔV direction is within 62 degrees of the sunline and use of the axial mode only when the ΔV direction is within 90 ± 25 degrees of the sunline. Figure 4.3.1.5.1-2 illustrates the weight penalty for vector mode vs. the available mode as a function of the angle between the spin axis cruise attitude and the ΔV direction. The vector mode is observed to have a maximum weight penalty of ≈ 7 lbs, when the required ΔV direction is ≈ 60 degrees above the ecliptic plane. The weight penalty associated with vector mode maneuvers for $90° < \theta < 150°$ is smaller than that for the no constraint case because the spacecraft must be nearly inverted to use the radial mode in this region. The penalty is still significant enough, however, that the available alternate mode (axial or radial) would be preferred for large ΔV maneuvers with troublesome directions in the north ecliptic hemisphere. For first midcourse ΔV maneuvers that are ≤ 8 meters/sec in magnitude, use of the vector mode would avoid operational difficulties while not requiring

propellant in excess of that loaded on board the spacecraft for a worst case ΔV correction.

4.3.1.5.2 ΔV Maneuver Tactics

4.3.1.5.2.1 Implementation of a ΔV Maneuver. The axial and radial thrusters onboard the Multiprobe constitute the set required to perform any ΔV without changing the prevailing attitude. The geometric arrangement of axial and radial thrusters relative to the spin axis, and the design of JCE control in the attitude Control Subsystem, permit the spacecraft to be translated successively in axial and radial directions with operational simplicity.

The thrust vectors of radial thrusters R3 and R4 are canted +28.5° toward the +Z axis from a plane parallel to the spacecraft X-Y plane, in order to pass through the center of mass that is estimated to apply at the required time for TCM #1. This set should be used for radial ΔV maneuvers prior to Large Probe separation. As the center of mass shifts toward the +Z axis due to expenditure of hydrazine fuel, subsequent usage of thrusters R3 and R4 will cause a coupled positive precession about a precession axis at $\theta = 322°30'$ (+X axis is at $\theta = 0°$).

The thrust vectors of radial thrusters R1 and R2 are canted +16.7° toward the +Z axis from a plane parallel to the spacecraft X-Y plane in order to pass through the center of mass that is estimated to apply after Large Probe separation. This set should be used for radial ΔV maneuvers after Large Probe separation. As the center of mass shifts toward the +Z axis due to expenditure of hydrazine fuel, subsequent usage of thrusters R1 and R2 will cause a coupled negative precession about the precession axis at $\theta = 322°30'$. The thrust vectors of axial thrusters A5 and A6 are parallel to the +Z axis.

Using the axial thruster(s) in continuous burn mode for an axial ΔV will result in a small precession if the angle burn duration is not an integer multiple of the prevailing spin period.

The command resolution for a ΔV maneuver, given the sensitivities shown in Table 4.3.1.3-4, and 0.512 second for the LSB in the ADP configure quantitative command for continuous firing mode (ATQØ4 or ATQØD), is

$$\frac{0.003\ \text{MPS}}{0.512\ \text{sec.}}$$ for a single axial jet.

Pulsed mode resolution is

$$\frac{0.006\ \text{MPS}}{\text{pulse}}$$ for a radial jet pair at 512 ms pulse duration.

4.3.1.5.2.2 Maneuver Parameters and Algorithms. Parameters that are significant for a ΔV maneuver are shown in Table 4.3.1.3-2. Their first order effect and algorithmic relationship are shown in Figures 4.3.1.5.2.2-1 and 4.3.1.5.2.2-2 for axial and radial ΔV maneuvers, respectively. Figure 4.3.1.5.2.2-3A shows that impulse magnitude error (essentially defined by thruster impulse uncertainty) is 2 percent, 3 percent and <3.1 percent in the axial, radial and vector modes, respectively. Figure 4.3.1.5.2.2-3B shows that the impulse directional errors (function of attitude uncertainty, open loop precession errors and execution errors) are <3 deg, <4 deg, and <2.5 deg in the axial radial and vector modes, respectively.

4.3.1.5.2.3 Restrictions. There are no restrictions unique to a ΔV maneuver beyond those general restrictions already cited in Section 4.3.1.3.

4.3.1.5.3 **Typical Command Sequence and Telemetry Verification.** Initial and changed spacecraft configurations for a typical radial ΔV maneuver (no precessions required), axial ΔV maneuver (no precessions required), total ΔV maneuver with axial jets only (precessions required), and total ΔV maneuver with radial jets only (precessions required) are shown in Tables 4.3.1.5.3-1, -3, -5, and -7, respectively. A detailed typical command sequence for each of these four types of ΔV maneuvers, with associated telemetry verification, starting with the spacecraft in-transit and in ecliptic-normal attitude, is shown in Tables 4.3.1.5.3-2, -4, -6, and -8, respectively.

TABLE 4.3.1.5.3-1

SPACECRAFT CONFIGURATIONS FOR A TYPICAL RADIAL ΔV MANEUVER

This is the same as Table 4.3.1.4.3-1 (Typical Precession Maneuver) with the following exceptions:

1. Pre-maneuver steady-state configurations for comm. S/S & bit rate prevail throughout the radial ΔV maneuver.

2. For "Attitude Data Processor - Jet Control - Just Prior to First Jet Fire", replace jet select combinations by:

   (R1 & R2 selected) or (R3 & R4 selected). - whichever produces a thrust vector directed closer to the prevailing S/C Center of Mass (i.e. that produces the smaller magnitude precession because of change in location of center-of-mass since launch).

TABLE 4.3.1.5.3-2

TYPICAL RADIAL ΔV MANEUVER SEQUENCE

This is the same as Table 4.3.1.4.3-2 (Typical Precession maneuver Sequence) with the following exceptions:

1. Replace all references to "precession" by "radial ΔV maneuver."

2. Replace jet select combinations for ATQØ2 command (ADP1 configure - Jet Control) by "(R1 & R2 selected) or (R3 & R4 selected)" and selection of 128 ms pulse width by selection of 512 ms pulse width (APULLS telemetry should read logical 1 (= 512 ms pulse width)).

3. Delete all changes to comm. S/S & Data Handling S/S.

TABLE 4.3.1.5.3-3

SPACECRAFT CONFIGURATIONS FOR A TYPICAL AXIAL ΔV MANEUVER

This is the same as Table 4.3.1.4.3-1 (Typical Precession Maneuver) with the following exceptions:

1. Pre-maneuver steady-state configurations for comm. S/S & Bit Rate Prevail throughout the axial ΔV maneuver.

2. For "Attitude Data Processor - Jet Control - Just prior to first jet fire":

   (a) Replace jet select combinations by: (A5 <u>or</u> A6 selected for continuous firing) <u>or</u> (A5 <u>or</u> A6 selected for pulsing at once per half spin periods)

   (b) For continuous firing: Continuous fire select & Time Count Select.

   (c) For Pulse firing: Pulse Fire, Pulse Count, Pulse width likely 512 ms., and either normal (one firing per spin period) or alternate mode (one firing per half spin period) - all selected.

3. For "ADP Configure - Commands ATQØ4 through ATQ12 - for continuous fire:

   (a) Replace all references to "Jet Countdown" by "Time Countdown".

TABLE 4.3.1.5.3-4

TYPICAL AXIAL ΔV MANEUVER SEQUENCE

This is the same as Table 4.3.1.4.3-2 (Typical precession maneuver sequence) with the following exceptions:

1. Replace all references to "precession" by "axial ΔV maneuver."

2. Replace jet select combinations for ATQØ2 command (ADP1 Configure - Jet Control) by "(A5 or A6 selected. For continuous fire, select continuous fire and time count. For pulsed fire - as shown, but select 512 ms. pulse width, and normal mode. Listed telemetry should indicate corresponding to that selected by command.

3. For a continuous firing: (a) ATQØ4 command (ADP1 Configure - jet countdown) must represent the time count in 0.512 second steps; (b) ATQØ5 command (ACS Angle Delay Magnitude) is omitted; (c) the on-board duty cycle detector is inhibited during continuous firing & the reference to "pulse loaded into the countdown circuit" is to be replaced by "... 0.512 msec, time counts loaded into the countdown circuit"; (d) PLINTI & PBUSLI will both definitely show a change in current level during a continuous firing; (e) AJMAGC (JCE Countdown) will be decreasing by one count per 0.512 msec.

4. Delete all changes to comm S/S & Data Handling S/S

TABLE 4.3.1.5.3-5

SPACECRAFT CONFIGURATIONS FOR A TOTAL ΔV MANEUVER WITH AXIAL JETS ONLY - (AXIAL MODE)

This will consist of a precession to the ΔV attitude followed by axial jet(s) burn continuously, followed by precession back to the steady state attitude. S/C Configuration changes shall conform to:

1. Precession to ΔV attitude - same as Table 4.3.1.4.3-1, except do not close latch valves needed for steps 2 & 3 ahead.

2. Continuous axial jet(s) burn - same as Table 4.3.1.5.3-3, except

   (a) Comm. S/S & data handling S/S shall be same status during the burn as for post precession, and
   (b) Do not close latch valves needed for step 3 ahead.

3. Precession back to steady - state attitude: Same as Table 4.3.1.4.3-1, except Comm. S/S & bit rate switch-over is in reverse order (from (FWD OMNI, HI XMTR PWR, 16 bps) to FWD OMNI, LOW XMTR PWR, 8 bps (worst case)).

TABLE 4.3.1.5.3-6

SEQUENCE FOR A TOTAL ΔV MANEUVER WITH AXIAL JETS ONLY - (AXIAL MODE)

1. Precession to ΔV attitude - same as Table 4.3.1.4.3-2 (typical precession maneuver sequence)

2. Continuous axial jet(s) burn - same as for Table 4.3.1.5.3-4 - except Comm. S/C & Data Handling S/S shall be the same status during the burn as for post-precession (already on FWD OMNI, XMTR HI PWR, 64 M. DSN, & 16 bPS).

3. Precession back to steady state attitude: Same as Table 4.3.1.4.3-1, except Comm. S/S & bit rate switch-over is in reverse order - complementary commands needed for this that are not shown in the Table.)

TABLE 4.3.1.5.3-7

SPACECRAFT CONFIGURATIONS FOR A TOTAL ΔV MANEUVER WITH RADIAL JETS ONLY - (RADIAL MODE)

This will consist of a precession to the ΔV attitude followed by radial jet(s) burn inpulsed mode, followed by precession back to the steady state attitude. S/C Configuration changes shall conform to:

1. Precession to ΔV attitude - same as Table 4.3.1.4.3-1, except do not close latch valves needed for steps 2 & 3 ahead.

2. Pulsed Radial jet(s) burn - same as Table 4.3.1.5.3-1, except

   (a) Comm. S/S & data handling S/S shall be same status during the burn as for post precession, and
   (b) Do not close latch valves needed for step 3 ahead.

3. Precession back to steady - state attitude: Same as Table 4.3.1.4.3-1, except Comm. S/S & bit rate switch-over is in reverse order (from (FWD OMNI, HI XMTR PWR, 16 bps) to (FWD OMNI,LOW XMTR PWR,8 bps (worst case)).

TABLE 4.3.1.5.3-8

SEQUENCE FOR A TOTAL ΔV MANEUVER WITH RADIAL JETS ONLY - (RADIAL MODE)

1. Precession to ΔV attitude - same as Table 4.3.1.4.3-2 (typical precession maneuver sequence)

2. Pulsed Radial jet(s) burn - same as for Table 4.3.1.5.3-2 - except Comm. S/C & Data Handling S/S shall be the same status during the burn as for post-precession (already on FWD OMNI, XMTR HI PWR, 64 M. DSN, & 16 BPS).

3. Precession back to steady state attitude: Same as Table 4.3.1.4.3-1, except Comm. S/S & bit rate switch-over is in reverse order - complementary commands needed for this that are not shown in the Table.)

4.3.1.6 Spin Rate Change and Trim Maneuvers

4.3.1.6.1 Spin Rate Change Maneuvers. Spin change maneuvers are most expediently done by firing radial thrusters continuously. Firing a pair of spinup or despin thrusters rather than a single thruster is always preferred in either continuous or pulse mode, in order to minimize attitude and velocity perturbations.

4.3.1.6.2 Unique Tactics for a Spin Rate Change

4.3.1.6.2.1 Implementation of a Spin Rate Change. The cant angles of the spin-up thrusters pair (R1 and R3) and spindown thrusters pair (R2 and R4) on the Multiprobe are different (+18.7° and -25.5°, respectively) so as to result in a small precession about the precession axis at θ 322°30', and a small ΔV toward the +Z axis. Using any single thruster for spin rate change will result in a larger precession and approximately the same axial ΔV as that obtained by use of the appropriate pair.

The command resolution for a spin rate change, given the sensitivities shown in Table 4.3.1.3-4, and 0.512 second for the LSB in the ADP Configure quantitative command for continuous firing mode (ATQØ4 or ATQØD), is approximately (0.056 RPM/0.512 sec.) for a radial jet pair, and (0.028 RPM/0.512 sec.) for a single jet.

4.3.1.6.2.2 Spin Rate Change Parameters and Algorithms. Parameters that are significant for a spin rate change are shown in Table 4.3.1.3-2. Their first order effect and algorithmic relationship are shown in Figure 4.3.1.6.2.2-1.

4.3.1.6.2.3 Restrictions. Beyond the general restrictions cited in Section 4.3.1.3, restrictions unique to a spin rate change include those described in Section 3.3.2.3.5 and 3.3.3.5 that are summarily reported here for emphasis: (1) the PLL loss of lock detection should be disabled except for spin trims within the PLL selected spin range since the PLL cannot track large spin speed changes, and will terminate the spin change maneuver if

loss of lock is detected (2) the sun gate should be disabled, except for spin trims within the PLL selected spin range since the spin period is changing, and an enabled sun gate would transfer the SRR to the simulated SRR after two consecutive missed sun pulses. A disabled sun gate also allows normal sun acquisition.

4.3.1.6.3 Typical Command Sequence and Telemetry Verification. Initial and changed spacecraft configuration for a typical 128 ms pulsed spin change maneuver (likely a spin trim) within the PLL selected spin range are shown in Table 4.3.1.6.3-1. A corresponding detailed sequence of commands and telemetry verification is shown in Table 4.3.1.6.3-2.

Initial and changed spacecraft configurations for a typical continuous or 512 ms pulsed (or 128 ms pulsed to produce final spin rate outside of the initial PLL selected spin range) spin change maneuver are shown in Table 4.3.1.6.3-3. A corresponding detailed sequence of commands and telemetry verification is shown in Table 4.3.1.6.3-4.

TABLE 4.3.1.6.3-1

SPACECRAFT CONFIGURATIONS FOR A TYPICAL 128 MS PULSED SPIN CHANGE MANEUVER (LIKELY A SPIN TRIM) WITHIN THE SELECTED PLL SPIN RANGE

This is the same as Table 4.3.1.4.3-1 (Typical Precession Maneuver) with the following exceptions:

1. Pre-maneuver steady state configurations for comm. S/S and bit rate prevail throughout the spin trim maneuver.

2. For "attitude data processor - jet control - just prior to first jet fire" replace jet select combinations by: R1 or R2 or R3 or R4 or (R1 & R3) or (R2 & R4) selected.

3. If the expected final spin rate is outside the pre-maneuver steady state selected spin range for "ADP Mode Select", then the maneuver described in Tables 4.3.1.6.3-3 and 4.3.1.6.3-4 should be followed.

4. For "ADP Configure Commands ATQ04 through ATQ12 - just prior to first jet fire" - add: PLL Spin period magnitude - set to expected final spin rate.

5. For "Attitude Data Processor - Spin Rate" -

   (a) "Between first jet fire and last jet fire" - add: "changing toward expected final spin rate."
   (b) "Immediately after last jet fire" - add: "at expected final spin rate."

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TABLE 4.3.1.6.3-2

TYPICAL SPIN TRIM (128 MS PULSED - WITHIN THE PLL SELECTED SPIN RANGE) MANEUVER SEQUENCE

This is the same as Table 4.3.1.4.3-2 (Typical Precession Maneuver Sequence) with the following exceptions:

1. Replace all references to "precession" by "spin trim maneuver."

2. ATQØ7 & ATQØ8 (or, equivalently, ATQ78) commands (ADP1 Configure - PLL Spin Period Magnitude - MSBs & LSBs) should load the expected <u>final</u> spin period <u>not</u> the initial spin period.

3. Replace jet select combinations for ATQØ2 command (ADP1 configure - jet control) by "R1 <u>or</u> R2 <u>or</u> R3 <u>or</u> R4 <u>or</u> (R1 & R3) <u>or</u> (R2 & R4) selected."

4. Delete all changes to Comm. S/S & Data Handling S/S - Retain scheduled switchover to and from ACS Data format.

5. Just after the post-maneuver issuance of ATQØ7 & ATQØ8 (ADP1 Configure - PLL Spin Period Magnitude), add:

CMD Mnemonic	Command or Action	Remarks & Verification: TM Mnemonic	Remarks & Verification: Remarks & TM Data
ATQØ3 SRXX as req'd.; PLE; SGA1; SGB1; SSRM; KEPSUN; STM; SUGE; SRRNRB	ADP1 Configure - ADP Mode Select (PLL Loss of lock enabled; sun gate enabled)	ASUNGS	= 1(Sun Gate Enable)
		ALOLES	PLL Loss of Lock = 1 (Enabled)
			All other TM - As Before

TABLE 4.3.1.6.3-3

SPACECRAFT CONFIGURATIONS FOR A TYPICAL CONTINUOUS OR 512 MS PULSED (OR 128 MS PULSED THAT REQUIRES CHANGE IN PLL SELECTED SPIN RANGE) - SPIN CHANGE MANEUVER

This is the same as Table 4.3.1.4.3-1 (Typical Precession Maneuver) with the following exceptions:

1. For "Attitude Data Processor - Jet Control" - Just prior to first jet fire":

   (a) Replace jet select combination by: R1 or R2 or R3 or R4 or (R1 & R3) or (R2 & R4) selected.

   (b) For continuous firing: Continuous fire select & time count select.

   (c) For pulse firing: As shown, but 512 ms (or 128 ms) pulse width selected, as applicable.

2. For "Attitude Data Processor - ADP Mode select" -

   (a) "Just prior to first jet fire", add:

      (1) PLL loss of lock inhibited.

      (2) Sun gate disabled

      (3) PLL spin range - selected to encompass expected final spin rate if it is outside of pre-maneuver steady state selected spin range.

   (b) "Assumed steady-state-post maneuver", add:

      (1) PLL loss of lock enabled.

      (2) Sun gate enabled

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TABLE 4.3.1.6.3-3. (Continued)

3. For "ADP Configure Commands ATQØ4 through ATQ12" - Just Prior to First Jet Fire" - add:

   PLL Spin period magnitude - set to expected final spin rate.

4. For "ADP Configure - Commands ATQØ4 through ATQ12" - for continuous fire:

   (a) Replace all references to "Jet Countdown" by "Time Countdown"

5. For "Attitude Data Processor - Spin Rate" -

   (a) "Between first jet fire & last jet fire" - add: "changing toward expected final spin rate."

   (b) "Immediately after last jet fire" - add: "At expected final spin rate".

TABLE 4.3.1.6.3-4

TYPICAL SPIN CHANGE (CONTINUOUS OR 512 MS PULSED) (OR 128 MS PULSED THAT REQUIRES CHANGE IN PLL SELECTED SPIN RANGE) - MANEUVER SEQUENCE

This is the same as Table 4.3.1.4.3-2 (Typical Precession Maneuver Sequence) with the following exceptions:

1. Replace all references to "precession" by "spin change maneuver."

2. ATQØ7 and ATQØ8 (or equivalently, ATQ78) commands (ADP1 Configure - PLL Spin Period Magnitude - MSBs and LSBs) should load the expected final spin period, not the initial spin period.

3. Replace jet select combinations for ATQØ2 command (ADP1 Configure - Jet Control) by "R1 or R2 or R3 or R4 or (R1 and R3) or (R2 and R4) selected." For continuous fire, select Continuous Fire and Time Count. For pulsed fire - as shown, but select 512 ms or 128 ms pulse width, as applicable; and Normal or Alternate Mode. Listed telemetry should indicate corresponding to that selected by Command.

4. Just before configuring downlink for forward omni usage, add the following:

TABLE 4.3.1.6.3-4. (Continued)

CMD Mnemonic	Command or Action	Remarks & Verification: TM Mnemonic	Remarks & Verification: Remarks & TM Data
ATQØ3: SRXX as Required; PLD; SGA1; SGB1; SSRM; REFSUN; [illegible]; SUGD; SRAXRM.	ADP 1 Configure - ADP Mode Select (New spin rate selected, if expected final spin rate exceeds present selected PLL spin range; PLL Loss of Lock inhibited; Sun Gate disabled)	ASUNGS	= 0 (sun gate disabled)
		ALOLES	PLL Loss of Lock = 0 (Inhibited - remains so throughout the maneuver).
		ASPINS	PLL spin range - encompasses expected final spin rate.
			All other TM - as shown in Table 4.3.1.4.3-2.

For a continuous firing: (a) ATQØ4 Command (ADP1 Configure - Jet Countdown) must represent the time count in 0.512 second steps; (b) ATQØ5 Command (ACS Angle Delay Magnitude) is omitted; (c) both the onboard duty cycle detector and PLL Loss of Lock circuit are inhibited during continuous firing and the reference to "... pulses loaded into the countdown circuit" is to be replaced by "... 512 msec. time counts loaded into the countdown circuit"; (d) PLIMTI and PBUSL1 will both definitely show a change in current level during a continuous firing; (e) AJMAGC (JCE countdown) will be decreasing by one count per 512 msec.

TABLE 4.3.1.6.3-4. (Continued)

Just after the post-maneuver issuance of ATQØ7 and ATQØ8, ADP1 Configure - PLL Spin Period Magnitude, add:

CMD Mnemonic	Command or Action	Remarks & Verification: TM Mnemonic	Remarks & Verification: Remarks & TM Data
ATQØ3: SRIX as Required; PLE; SGA1; SGB1; SSRM; REFSUN; STN;SUGE; SRANRM	ADP1 Configure - ADP Mode Select (PLL Loss of Lock enabled; sun gate enabled)	ASUNGS	= 1 (Sun Gate Enable)
		ALOLES	PLL Loss of Lock = 1 (Enabled)
			All Other TM - As Before.

4.3.2 <u>Attitude Determination</u>. Attitude determination strategy and tactics are described below. A discussion of attitude estimation, the overall mission timeline and the typical command sequence with corresponding telemetry verification are included.

4.3.2.1 <u>General Description</u>. Attitude determination includes all data collecting and data processing necessary to establish the spacecraft attitude (direction of the angular momentum vector) w.r.t. inertial (fixed) coordinates in three-dimensional space. The spacecraft attitude is determined as precisely as practical in order to (1) insure optimum thrust vector orientation for the hydrazine thrusters, and, (2) achieve satisfactory orientation for (a) release of the Large and Small Probes, and (b) the Bus Experiments at Bus Entry.

Attitude determination may be done (1) in a "quick-look" manner, i.e., with a few samples of data to establish approximately that a desired attitude prevails, or (2) in a "refined" manner, where numerous samples of data from various spatial sources are statistically processed with estimates of sensors biases in order to achieve an accuracy of 0.5° or better. The "refined" approach seeks to minimize random errors by appropriate data averaging; and to minimize systematic errors (i.e., biases) by quantitatively identifying their up-to-date values. The biases may change due to several causes such as thermal effect on mechanical alignment, fuel-depletion effect on mass properties, and change-in-spacecraft-location effect on intensity of, and angle subtended by the spatial reference(s) (such as the sun or earth).

4.3.2.2 <u>Strategy</u>. A general description and the use of two or more spatial references are described below.

4.3.2.2.1 <u>General</u>. Strategy is the basic plan.

Specific strategy for "quick-look" attitude determination consists essentially of (1) collecting a few samples of data of two spatial references, (2) defining the approximate spatial position of the spacecraft and angles between lines of sight to the two spatial references, and (3) processing the data minimally by on-line computer or graphical aids to determine the approximate spacecraft attitude.

Specific strategy for "refined" attitude determination consists essentially of (1) collecting many successive samples of data of lines-of-sight to at least two and preferably three or more point-source spatial references, (2) defining the accurate spatial position of the spacecraft, the angles between lines-of-sight to all spatial references, and up-to-date estimates of biases to be eliminated from the telemetered data, and (3) statistically processing the data via off-line computer to determine the spacecraft attitude as accurately as practical.

4.3.2.2.2 <u>Use of Two or More Spatial References</u>. Collection of data on the line-of-sight to two or more spatial references is sufficient to define spacecraft attitude in inertial (fixed) coordinates.

The accuracy of the results is generally commensurate with the numbers of spatial references beyond two that are used, the amount of data collected and processed to minimize the random errors, and the accuracy of estimation of the systematic errors. Additionally, the accuracy will be degraded when lines-of-sight to spatial references are nearly colinear such that measurements become redundant.

The effect of random errors can be minimized by appropriate statistical averaging, hence the need for collection of many successive samples of data. The systematic errors include contributions by:

(a) Orbit or trajectory determination errors and their effect on choosing the correct ephemeris data.
(b) The angle subtended by the spatial reference, such as the sun. A point source such as a star is inherently a more accurate spatial reference than the sun.
(c) Mechanical alignments and electrical boresight alignments of sensors, and the effect of thermal distortion upon them.
(d) Sensor calibration uncertainty.
(e) Variation in sensor threshold detection.
(f) Spacecraft wobble.

Representative values for these contributors, excluding the effect of item (a) above, are shown in Table 4.3.2.2-1.

4.3.2.3 Tactics. A general description, attitude sensors and data types, attitude determination, attitude estimation, sun and stars availability during the nominal mission, and an overall mission timeline for attitude determination/estimation are described ahead.

4.3.2.3.1 General. Tactics consist of the specific implementation of the strategy, unique to the spacecraft design and to the point in the mission.

The preferred method for determining Multiprobe spacecraft attitude, via use of sun-to-star(s) roll angle and aspect angle measurements, is functionally independent of the point in the mission, but the choice of stars varies during the mission, as described in Section 3.0 and ahead. Further, the accuracy of determination will vary during the mission for reasons already cited in Section 4.3.2.2.2.

Multiprobe spacecraft attitude sensors and data types, attitude determination, attitude estimation, availability of spatial references during the mission, and overview timelines are described ahead.

4.3.2.3.2 Attitude Sensors and Data Types. The attitude control subsystem uses sun and star sensors to effect attitude and spin rate measurements. Each sensor has a vertical and a canted slit; ψ and ψ_2 for the sun sensor; ψ^* and ψ_2^* for the star sensor. Any one of the ψ, ψ^*, or $\psi\psi^*$ slits can be used as an azimuthal reference (SRR-selected roll reference) for the purpose of making azimuthal angle measurements (via telemetry of time intervals between occurrences) to ψ, and to any star, including the reference star, using the ψ^* or ψ_2^* slit. The geometry of attitude sensor measurements is summarized in Figure 4.3.2.3-1. Further description of the sun and star sensors is detailed in Section 3.3.

The primary and secondary data types employed in the attitude determination process are also shown in Figure 4.3.2.3-1. The three primary data types are sun aspect angle ($\psi\psi_2$), sun-to-star roll angle with the vertical star slit ($\psi\psi^*$), and sun-to-star roll angle with the canted star slit ($\psi\psi_2^*$). The ACS mechanization also permits direct measurements of star aspect angle ($\psi^*\psi_2^*$), star-to-star roll angle with the vertical star slit ($\psi^*(1)\psi^*(2)$), star-to-star roll angle with the canted slit ($\psi_2^*(1)\psi_2^*(2)$), and star-to-star roll angle with the vertical and canted star slits $\psi^*(1)\psi_2^*(2)$. These latter four data types can also be derived from the three primary data types.

There are two kinds of errors associated with each data type: random and bias. The random component is caused by threshold jitter, pulse-to-pulse jitter, residual spacecraft rotation and quantization effects. The bias component is caused by leading edge and threshold uncertainty, sensor misalignment, calibration uncertainty and spacecraft wobble. All error sources except the leading edge and threshold uncertainty generate a

bias which is a function of the sun and star aspect angles. However, the effects of all these error sources on the bias of any data type can be obtained from errors in the pairs of angles that define the orientations of all sensor slits. In other words, if each slit is represented by an azimuth angle (defined by the intersection of the slit with the actual spin plane) and a cant angle (defined by rotation about this line of intersection), then errors in these two angles for each slit involved in the measurement of any data type can always be made equivalent to any of the error sources noted above.

4.3.2.3.3 Attitude Determination. Attitude determination, aside from estimation of attitude errors (discussed ahead), employs three schemes that are shown in Table 4.3.2.3-1, along with associated data types, required sensors, and minimum number of required visible stars and measurements. Advantages and disadvantages associated with each scheme are shown in Table 4.3.2.3-2.

4.3.2.3.4 Attitude Estimation. The need for bias estimation is based on the following essential considerations:

(a) Relative azimuth bias in the spin plane between two slits distorts measurements.
(b) Relative cant bias with respect to spin plane between two slits distorts measurements.
(c) Relative azimuth and cant between those slits employed in the measurement process must be estimated to eliminate any out-of-spec attitude error due to sensor biases.
(d) Sun sensor requires estimation at two different attitudes to distinguish between the relative azimuth and cant biases of the ϕ and ϕ_2 slits.

The need for bias estimation is illustrated quantitatively in Figure 4.3.2.3-2. Regardless of the schema employed, attitude determination using telemetry alone is not sufficient to reduce the error in spin axis attitude to the 0.5° or less requirement of PC-410 (Reference: Section 1.5.4). Data smoothing and estimation of biases will result in a less than 0.5° error in attitude for the appropriate geometry.

The approach taken in the "refined" attitude determination process is to estimate attitude errors (biases) in those pairs of angles that define slit orientations. While the bias component of the data types is not estimated directly, the mean of the residuals (observed minus computed data) is a measure of how good the estimation is. The attitude estimation algorithm uses this approach.

Four basic attitude estimation schemes, defined by which data types are employed with the estimator, can be identified. The primary scheme (Scheme 1) uses sun aspect angle and sun-to-star roll angles with two star sensor slits. The secondary scheme (Scheme 2) uses sun aspect angle and sun-to-star roll angles with one star sensor slit.

A summary of the various attitude estimation schemes, their data types, number of required measurements (to meet the 0.5 degree attitude determination accuracy) and estimated biases is presented in Table 4.3.2.3-3. Advantages and disadvantages associated with each scheme are shown in Table 4.3.2.3-4. Note that while the first scheme requires the greatest number of measurements, it also requires the fewest number of visible stars, three. Note also that the relative biases estimated using Scheme 1 include or can be used to define those associated with Schemes 2 and 3, and approximate those associated with Scheme 4. Because of these relative advantages, Scheme 1 can be considered the baseline type of attitude estimation. Scheme 3 also employs both star sensor slits and requires four measurements; the latter advantage is offset

by the requirement for four visible stars and added complexity of using a star as the selected roll reference. Scheme 2 requires an additional visible star (relative to Scheme 1) to compensate for the use of only one star sensor slit. Scheme 4 requires the fewest measurements and only one slit; however, four visible stars are required and the fewer measurements relative to Scheme 2 is offset by the added complexity of using a star as the selected roll reference. Schemes 1 and 2 have been examined in detail with respect to the Pioneer Venus mission profile because (i) Scheme 1 essentially solves for all the observable biases with the fewest number of stars; (ii) both schemes employ the sun as an easily detectable selected roll reference, i.e., avoiding a star roll reference by using an increased number of measurements; (iii) "Complete" bias estimation need not be done continuously, only periodically to account for drift and mass properties changes; and (iv) Only one star and one star slit is required to define attitude after each bias "update".

4.3.2.3.5 Sun Availability During the Nominal Mission. For nearly all of the nominal mission, the sun line-of-sight will remain well within the sun sensors' fields-of-view. The period of time when the sun l.o.s. may fall outside the sensors' fields-of-view begins immediately after launch and automatic spacecraft spinup to a nominal 15 rpm. At that time, the average sun look-angle will be approximately 90° (Refer to Sections 4.1.1.1 and 4.1.1.2). During cruise, the sun l.o.s. is expected to remain well within the mid-range sun sensor's field-of-view. During encounter maneuvers, sun angles range from 20 to 50 deg., so that the upper extended range sun sensor will be the primary observer (Refer to Section 4.1.1.2).

4.3.2.3.6 Star Availability During the Nominal Mission. The Multiprobe cruise mission and the encounter maneuvers were simulated using the above estimation techniques to ascertain the feasibility of meeting the attitude determination accuracy specifications. Since the accuracy of

the estimator is dependent upon the number of independent measurements, and therefore, the number of stars sighted, bar charts of star availability were created for the probe cruise phase of the mission. Figures 4.3.2.3-3 is a time line bar chart showing the availability of visible stars for each star sensor slit when not interferred with by the sun. Figure 4.3.2.3-4 is a time line bar chart indicating the total number of visible stars by either star sensor slit. For the probe cruise, where the attitude is nominally at the south ecliptic normal, it could be advantageous to reorient the attitude to (ecliptic latitude) θ = 178°, (ecliptic longitude) ϕ = 0° to potentially acquire Gacrux and Fomalhaut.

A quick look at these charts indicates that four or more stars are available 100 percent of the time for the probe cruise. For the failure mode, when one star sensor slit is inoperative, the required four stars needed for complete observability are therefore available.

Figures 4.1.1.2-9 and 4.1.1.2-10 depict the potential attitudes and star availability for the Large and Small Probe release maneuvers for a 9 December 1978 arrival date.

4.3.2.3.7 Overall Attitude Estimation Accuracy. Table 4.3.2.3-5 lists some prominent events in the nominal mission when an attitude determination, either "Quick-Look" or "Refined", in conjunction with an attitude estimation, are recommended to occur.

4.3.2.4 Typical Command Sequences and Telemetry Verification. The Initial Spacecraft Configuration for a typical attitude determination sequence is shown in the "Assumed Steady-State (Pre-Maneuver)" column of Table 4.3.1.4.3-1.

The feasible telemetered data types for use in determining or estimating attitude are shown in matrix format in Table 4.3.2.4-1. A specific step-by-step command sequence, that includes

corresponding telemetry verification, for each telemetered data type is identified by Table number in each cell of this matrix. All of these tables are included in this Section 4.3.2.4.

4.3.3 Roll References. The feasible combinations for establishment or transfer of Selected Roll Reference are shown in Matrix format in Table 4.3.3-' A specific step-by-step command sequen , that includes corresponding telemetry verifi..tion, for each SRR transfer combination is identified by Table number in each cell of this matrix. All of these tables are included in this Section 4.3.3.

4.3.4 Multiprobe Power and Thermal Operations. This section describes the power load and heater configurations, solar panel performance, and battery management for all of the various Multiprobe critical mission events.

4.3.4.1 Multiprobe Load Management. The Multiprobe load configurations are shown in Table 4.3.4.1-1 in chronological order. The start time for each mission phase is indicated at the top; launch (L) is the zero time reference. The sun angles with reference to the spin axis and the solar distances are also listed. The latter determines the effective solar intensity, which varies from 0.974 near Earth to 1.933 near Venus.

All loads are grouped by subsystems. The electrical nature of the load is defined by a letter: P for constant power, I for constant current and R for constant resistance. The operational mode of each load for each mission phase is also indicated: on, standby, or off.

The total spacecraft load, listed near the bottom of the table, represents the power required by all spacecraft loads, including science. This amount of power must be supplied by either the battery, the solar panel, or in a shared battery/solar panel mode.

The minimum available solar panel current at 28 volts and the margin, or contingency, are shown

at the bottom of the table. Battery current, ampere-hours consumed and battery depth of discharge (DOD) are also listed for those mission phases where the battery is active.

Available solar panel power is a function of solar constant, sun angle and radiation loss. The solar panel power listed in the table assumes that a massive solar flare has occurred. It also includes a 2 degree solar angle uncertainty. If solar flare activity during the mission is not severe, additional solar panel power will be available.

The loads shown in the table are based on actual measurements but they still have a small amount of conservatism to allow for measurement error, aging effects, etc. Also, the budget allowance for Bus science is very generous. Actual science loads are somewhat lower and during cruise are turned on only for short checkout periods.

4.3.4.1.1 Prelaunch, Launch and Spin-up. The prelaunch and launch loads shown in the table are powered from the blockhouse until 30 minutes before liftoff, at which time power is transferred to spacecraft batteries.

The total battery DOD expected for pre-launch, launch, abd spin-up is 27.1 percent. The battery charging circuitry is commanded into the low rate charge state prior to launch so that the batteries will be recharged soon after the sun is acquired.

Actuation of the spacecraft separation switches initiates a command sequence stored in the command memories. These automatic commands turn on both Attitude Data Processors (ADP), turn on spin-up jets for approximately 120 seconds, and then turn off one of the redundant ADP units.

To prevent trip-off of the switched loads and rf transmitter power buses during launch due to vibration induced relay contact chatter, the override or "power system not protected" relay is turned on during pre-launch via PSP1Ø or PSPAØ,

"Power System Protection OFF." This switches in a redundant path for those power buses.

4.3.4.1.2 Cruise. Shortly after initial ground station acquisition, the following events occur:

(a) The UV/OL switch is commanded to "power system protection on".
(b) Both command memories are turned off.
(c) The star sensor is turned on.
(d) The Large Probe heater is turned on.

Thirty watts of solar panel power is allocated to science for operation of the Bus instruments. However, BIMS and BNMS require only approximately 5 watts and they operate only for short time periods during science checkout periods.

During the initial cruise phase, which continues until entry minus 28 days, the solar panel spin axis is normal to the sun. As shown by Table 4.3.4.1-1, there is a minimum of 2.10 amperes surplus current near Earth that is available to heat the equipment shelves.

The Bus shelf heaters will probably stay on until approximately L+60 days. At this time, the shelf temperatures will increase and the shelf thermostatic switches will automatically turn off and deactivate their associated voltage limiters.

The Large Probe shelf heaters will probably be needed until L+80 days. However, if the probe forward shelf temperature reaches +55°F before this time, the heater should be turned off to prevent degradation of the probe silver zinc battery.

After the probes are released, the Bus spacecraft sun angle will be between 40 and 60 degrees. The solar panel output at this time will be more than adequate to operate the spacecraft without battery power.

4.3.4.1.3 Thrust Correction Maneuvers. All thrust correction maneuvers before reorientation are planned to be performed with the spin axis

perpendicular to the sun line. The only additional major load, beyond the cruise loads, is a jet thruster solenoid. Therefore, the batteries will not be needed during the TCMs, assuming the planned attitude for these maneuvers. The solar panel will continue to support all loads and maintain the bus voltage at 29.5 volts.

Small Probe and Bus Targeting maneuvers are performed at lower sun angles, but there will be adequate solar panel current to meet all load requirements without the need for battery support.

4.3.4.1.4 Probe Checkouts. Small and Large Probe checkouts are scheduled to start at L+60 days, when the second S-band amplifier is commanded on.

If probe checkout current is limited to 3 amperes, the solar panel will provide all required power without supplemental battery current. Table 4.3.4.1-1 shows a worst case power configuration wherein 56 watts is provided to the Large Probe science instruments after reorientation at a sun angle of 49 degrees. This will allow low rate charging to continue during probe checkouts and still provide a solar panel contingency of 0.605 amperes.

To prevent excessive thermal dissipation in the Large Probe during checkouts, the Large Probe shelf heaters should always be turned off initially and then turned on again, if necessary, after the checkout is completed.

4.3.4.1.5 Reorientation (Horn Operation). On day E-28, the spacecraft spin axis is reoriented to a sun angle of approximately 49 degrees and the horn antenna is pointed toward Earth. This will sharply increase the Large Probe temperature and the probe shelf heater must be turned off. Table 4.3.4.1-1 shows a minimum contigency of 3.33 amperes. The Table assumes that only one 10 watt S-Band Power Amplifier is turned ON, but a second S-Band power amplifier can be easily accommodated.

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During the entire cruise period, the Bus batteries will be on low rate trickle charge. Since the Bus batteries will be required to provide large pyro currents during Large Probe separation (and support spacecraft loads if sun angle is low at this time), it is desirable to maximize their stored energy to guarantee that they will provide the minimum required 5 amperes per bridgewire (3 bridgewires per battery) at the required minimum pyro bus voltage of 17.6 volts. This is accomplished by charging at the high rate. This must be accomplished before precession to the low sun angle Large Probe release attitude. At low sun angles, the high charge rate is sharply reduced. High charge rate should be continued until the battery voltages "roll-over". (As the batteries charge, their voltage slowly rises and after full charge is achieved, their voltage peaks and then starts to decrease. After this occurs, low rate charging should be resumed.)

4.3.4.1.6 Large and Small Probe Separation. Large Probe separation can occur over a 24.5 to 37.0 degree range of sun angles. The solar panel will be able to supply all spacecraft loads at sun angles exceeding approximately 28 degrees. At lower sun angles, the batteries must augment the solar panel. Table 4.3.4.1-1 describes a worst case at the lowest sun angle. Battery DOD is 26.7 percent for 4 hours of operation.

During Large Probe separation, battery charge should be in low rate charge to minimize battery temperature rise. After Large Probe release, the spacecraft spin axis is precessed to a higher sun angle. The Bus batteries should then be recharged again at a high charge rate until "roll-over" and then commanded back to a low charge rate.

Small Probe separation occurs at low sun angles that range from 17 to 26 degrees. At the higher sun angles, unrestricted high power S-band operation is possible. At the lower sun angles, it will be necessary to restrict the amount of time on high power to limit the maximum battery

DOD to 60 percent. During L.P. release and S.P. release, a UV/OL failure that results in a trip of the non-essential buses could be catastrophic. Therefore, it would be prudent to command the UV/OL to "Power System Protection OFF" (override) approximately 1 hour before each event, and then command "Power System Protection ON" again after each of these two events.

4.3.4.1.7 Atmosphere Entry. Prior to atmosphere entry, The solar panel supplies all spacecraft and Bus instrument loads. During entry, the panel will heat up rapidly and the batteries will then support all loads until the spacecraft disintegrates.

4.3.4.1.8 Solar Panel Surplus Power. All solar panel contingency values, shown in Table 4.3.4.1-1, specify the surplus current at 28.0 volts. The fact that a surplus exists forces the solar panel voltage upward above 28 volts. If the shelf thermostatic switches are off, the voltage limiters will clamp the power buses at 29.5 volts. If the solar panel is relatively cold and operating over the constant current portion of the solar panel V/I curve, the voltage limiter current at 29.5 volts will be equal to surplus current available at 28 volts. However, if the panel is relatively warm (i.e., near Venus), the operating point will be on the knee of the curve (See Section 4.3.4.3). This means that when the voltage is driven upwards, due to available surplus current, the solar panel current will decrease and the voltage limiter current will be somewhat less than indicated in Tables 4.3.4.1-1. If the surplus at 28 volts is small, there may not be enough current available to drive the panel voltage as high as 29.5 volts. The quiescent stable voltage will then be some value between [illegible] and 29.5 volts, and there will be no voltage limiter current.

The solar panel power/current values shown in Table 4.3.4.1-1 are conservative minimum values. It is anticipated that there will be sufficient current available to force the voltage limiters

into conduction at all times except during Large and Small Probe release.

4.3.4.2 Use of Propulsion and Shelf Heaters. Section 3.2 provides a detailed description of the thermal design, including the propulsion heaters.

The propulsion tank heater group is on continuously. At launch the primary group is selected by ground command. Failure of any one of 12 heaters in this group can be determined by temperature sensors and/or special high resolution current sensors (described in Section 3.8.3.8). If a failure occurs, the redundant secondary group can be selected by ground command. Either the primary or redundant tank group heaters are on at all times. They cannot be commanded off. The latch valve and fill and drain heater current sensors monitor only the primary heaters. If the secondary group of heaters is selected, these two TM signals will read zero.

The radial thrusters and line heaters are on continuously also - they cannot be command off.

The axial thruster and line heaters are commandable. They are both turned on at launch. The forward axial heater is turned off after the horn reorientation maneuver.

Operation of the equipment shelf heaters is described in Sections 3.2 and 3.8.2.3. The battery shelves will cool down after launch and limiter 5 will conduct. This will provide approximately 33 watts to the battery shelf heaters and another 33 watts to the RF shelf heaters. If voltage limiter 5, or one of its associated thermostatic switches fails, limiter 2 on the RF shelf provides a back-up capability and delivers the same amount of heat to the two shelf sections. The shelf heaters will probably stay on until approximately L+60 days. At this time, the shelf temperatures and thermostatic switches will be high enough to automatically turn off the shelf heaters.

The shelf heaters will also come on automatically if the shelf temperatures reach excessively low values due to an undervoltage/overload switch trip.

Each Small Probe has a 2.0 watt forward shelf heater. These heaters probably will not be needed because the Small Probe forward shelf temperature will probably stay above the minimum required value of +5°F. However, if the shelf temperature drops below this value, the heater must be turned on. When the Small Probe forward shelf reaches +55°F, the heater must be turned off.

The Large Probe has a 2.4 watt aft shelf heater and a 19.1 watt forward shelf heater. After launch, the Large Probe forward shelf (and battery) temperature will slowly decrease. The probe shelf heaters must be turned on when the forward shelf temperature reaches +5°F. When the shelf temperature rises to +55°F, the Large Probe heater must be turned off.

The probe shelf heaters must be turned off prior to the initiation of probe checkouts. This will prevent overheating the probe silver zinc batteries and help maintain their capacity at the required level.

4.3.4.3 Solar Panel Performance by Mission Phase. The Multiprobe solar panel performance is summarized by the voltage/current curves shown in Figures 4.3.4.3-1 and 4.3.4.3-2. These curves represent the minimum and maximum output that will be available.

The solar panel sun angle history is shown in Figure 4.3.4.3-3. The panel voltage/current characteristics, of course, are highly dependent upon sun angle. At sun angles below 30 degrees shadowing from the radial thrusters and star sensor sun shield results in a small decrease in panel output. The curves shown in Figures 4.3.4.3-1 and 4.3.4.3-2 indicate average output that reflects this shadow loss. Sun angles after horn reorientation on E-28 days can vary over a

small range of values. The sun angle that will obtain during the mission will be a function of launch date and probe target locations.

4.3.4.4 Battery Management. Battery charging will be commanded to low charge rate at launch. It will remain in low charge rate during the entire mission except for the short time periods indicated below. As explained in Section 3.8.3.4, the nominal charge rate will be approximately 125 ma for a solar panel that has experienced maximum radiation degradation. The nominal charge rate will probably be closer to 150-175 ma.

Approximately one day before Large Probe release, both batteries should be commanded to high rate charge. High rate charge should be maintained until the battery voltage "rolls over". This will maximize capacity and voltage under heavy load (required for pyro firings).

High rate charging should again be commanded on approximately one day before Small Probe release until battery voltage "roll over" occurs.

Following Small Probe release, high rate charge should be commanded on again until "roll over". If Bus targeting is performed at sun angles below 25 degrees, it may be necessary to use the battery again during this phase.

Bus battery charge management is summarized in Table 4.3.4.4-1.

4.3.5 Probes Checkout. The Large Probe may be checked out electrically nominally anytime after L+60 days and prior to separation from the Bus. The Small Probes may be checked out electrically anytime between initial ground station acquisition and prior to separation from the Bus. Commandable engineering and scientific instrument functions (except for nonreversible functions) can be verified and operating characteristics determined for the cruise operating environment. The Bus will provide checkout power, communications, telemetry of the checkout data,

and control of the realtime or stored checkout commands. Each probe will provide formatted probe data modulating a probe-generated telemetry subcarrier.

The Bus can only transmit one probe subcarrier (and either of two probe bit rates) at a time without creating distortion in the data stream. A Bus subcarrier containing any Bus data format at any bit rate supportable in the link budget can be transmitted simultaneously.

4.3.5.1 Thermal and Power Constraints. The thermal and power constraints which limit probe checkout are discussed in Sections 5.1.2.1.2 and 5.2.2.1.2 for the Large and Small probes, respectively. In summary, Large Probe checkout cannot be performed before approximately the 60th day after launch because the Large Probe's temperatures are below the minimum operating limit, whereas the Small Probe's temperatures are expected to be above the minimum operating limits throughout the cruise phase. Any one or more scientific instruments on any probe may be operated indefinitely during checkout of that probe as long as [SXPW1T AND SXPW2T AND PXBATT are all ≤ +85°F] AND [SXAP1T AND SXAP2T are both ≤ +122°F], where X = L for the Large Probe, or = 1 or 2 or 3 for SP1 or SP2 or SP3 respectively. Once any limit is reached the equipment should be turned OFF, and checkout of that probe should not be resumed until the telemetered temperature that indicated the limit level has decreased by ≥ Δ5°F.

4.3.5.2 Subsystem Operating Characteristics and Constraints. Except for probe internal data formatting, probe checkout utilizes Bus subsystems. Details of the command, data handling, communications and power operating characteristics and constraints during probe checkout are discussed in Sections 5.1.2.1.2 and 5.2.2.1.2 for the Large and Small Probes, respectively.

4.3.5.3 Probe Checkout Sequence. Table 4.3.5.3-1 presents a representative probe checkout sequence for the Large and Small Probes. The sequence is

divided into five parts: 1) Bus Preparation, 2) Probe Preparation, 3) Functional Checkout, 4) Probe Reconfiguration, and 5) Post Checkout Return to Initial Conditions.

The commands required in Subsequence 1), Bus Preparation, depend on the initial conditions and the desired mode of operation: High or low power, forward or aft omni antenna, etc. The particular subsequence 1) in Table 4.3.5.3-1 is representative. The assumed initial conditions and operating configuration are indicated. Similarly, details of subsequence 2), Probe Preparation, depend on the desired data rate and format. The particular subsequence 2) in Table 4.3.5.3-1 assumed utilization of the format and data rate initialized at C/DU turn on. The order of commands in subsequence 3), Functional Checkout, is also arbitrary. The specific selection of these commands depends on which functions are to be checked out. The order of commands presented in the table allows checkout of all controllable engineering functions with the minimum number of commands.

Checkout of controllable scientific instrument functions will be performed in combination with the engineering sequence. The scientific instrument commands which are available for checkout are listed in PC-455, Reference Paragraph 1.5.1.

A representative time to perform scientific instrument checkout is indicated within Subsequence 3). The engineering commands are indicated which must precede scientific instrument checkout to establish the desired format and data rate and to connect power to the science bus.

Once the C/DU is turned on, the format and data rate are automatically initiated and all telemetry channels are available in the probe data stream. As long as the data mode is not changed by command, all engineering commands can be executed and the response verified.

By turning OFF the probe checkout power (the first command of Subsequence 5)), all probe subsystems are turned OFF. This is the fastest shutdown approach in the event of an emergency. However, this leaves the probe magnetic latching relays in their last state and not in the state desired at initial turn on. Subsequence 4) reconfigures the probes to the desired initial configuration. This sequence should be used whenever unexpected (but not emergency) shutdown is required. Furthermore, even during normal operation, as represented by Subsequence 3), the entire reconfiguration sequence can be performed prior to final turn off of the probe command/data unit. This provides additional assurance that all relays have been reconfigured to their initial states, i.e., turned OFF.

Final Subsequence 5), Post Checkout and Return to Initial Conditions, is the converse of Subsequence 1). If a different operating mode is established than that described by Subsequence 1), appropriate changes must be made to Subsequence 5).

TABLE 4.3.1.3-1

THRUSTER USAGE

MANEUVER	JET CONTROL MODES (PRIMARY AND BACKUP)
Spin Control	
Spinup	1) R1 and R3 Continuous 2) R1 Continuous 3) R3 Continuous
Spindown	1) R2 and R4 Continuous 2) R2 Continuous 3) R4 Continuous
Canted Radial ΔV	1) R1 and R2 Pulsed Simultaneously at spin frequency. 2) R3 and R4 Pulsed Simultaneously at spin frequency.
Axial ΔV	1) A5 Continuous 2) A6 Continuous 3) A5 Pulsed at Twice Spin Frequency. 4) A6 Pulsed at Twice Spin Frequency.
Attitude Precession	1) R1 and R2 or R3 and R4 pulsed Simultaneously at Spin Frequency. 2) R1 and R4 or R2 and R3 Pulsed Simultaneously at Spin Frequency. 3) A5 and A6 Pulsed Simultaneously at Spin Frequency. 4) A5 Pulsed at Spin Frequency. 5) A6 Pulsed at Spin Frequency.

TABLE 4.3.1.3-2

MANEUVERS PARAMETERS

Units		Parameters	Equation Symbol	Parameter Affects the Maneuver: ΔV Radial	ΔV Axial	Spin Change	Precession
Lb		S/C Weight	W	Yes			
Slug-Ft^2		Spin Moment of Inertia	I_3	Yes			
None		Spin to Transverse Inertia Ratio	σ	Yes			
None		No. of Radial Jets Fired	Q = NRJETS-1	No	No	Yes	No
In.		Radius to Radial Jets	R	Yes	No	Yes	No
In.		Axial location of Radial Jets relative to c.g.	L	Yes			
Deg.		Tilt Angle of Jets 1R & 2R	γ_1				
Deg.		Tilt Angle of Jets 3R & 4R	γ_2				
Deg.		Location in transverse plane of radial jets	β				
Lb.		Radial Jet Thrust	F				
None		No. of Axial Jets Fired	K	No	Yes	No	Yes
In.		Radius to Axial Jets	R				Yes
In.		Axial location of axial jets fired relative to cg	L				No
Lb.		Axial Jet Thrust	F				Yes
Sec.		Specific Impulse	I_{SP}	Yes			
RPM		Initial Spin Speed	ω_0				
Lb.	Uncertainties	S/C Weight	δW				No
Deg.	Uncertainties	Thrust Misalignment	ϵ				
Deg.	Uncertainties	Thruster Misalignment	$\delta\beta$		No	Yes	Yes
Deg.	Uncertainties	Principal Axis Tilt	τ				
Deg.	Uncertainties	Jet Pulse Timing Circuit	$\delta\theta$		No	No	Yes
In.	Uncertainties	Radius of Jets	δR		Yes	Yes	Yes
In.	Uncertainties	Axial Location of Jets	δL		No	Yes	No
In.	Uncertainties	Sun Pulse	$\delta\alpha$		No	No	Yes
Sec.	Uncertainties	Thrust Centroid	δt_c		No	No	Yes
Deg.	Uncertainties	Initial attitude (Rotation about inertial X Axis)	X		No	No	No
Deg.	Uncertainties	Tilt Angle of Jets	$\delta\gamma$				
Lb.	Uncertainties	Thrust Magnitude	δF				
Slug-Ft^2	Uncertainties	Spin Inertia	δI_3	No	No	Yes	Yes
Sec.		Pulse Burn Duration	T				
MPS		Desired Radial ΔV	ΔV_{Radial}				
Deg.		Initial attitude (rotation about inertial Y Axis)	Y				
Sec.		Uncertainty in Burn Duration	δT				
MPS		Desired Axial ΔV	ΔV_{Axial}				
RPM		Final Spin Speed	ω_f				
Sec.		Uncertainty in Burn Duration	δT				
RPM		Uncertainty in Spin Speed	$\delta\omega_f$				
Sec.		Burn Duration	T				
Deg.		Desired Precession	None				

NOTE: These parameters are used in Figures 4.3.1.4.2.3-1, 4.3.1.5.2.2-1, 4.3.1.5.2.2-2, & 4.3.1.6.2.2-1.

TABLE 4.3.1.3-3

SUMMARY OF NOMINAL MANEUVER CHARACTERISTICS

Maneuver	Jet Selection	Mode (Pulse Width, Ms)	Nominal Performance During Cruise at 15 RPM		Nominal Performance After LP Separation at 48.5 RPM	
			Control	Efficiency	Control	Efficiency
Attitude Precession	1) Axial Jet Couple	Pulse (128)	0.10 Deg/ Pulse	69 Deg/Lb	0.029 Deg/ Pulse	23 Deg/Lb
	2) Single Axial Jet	Pulse (128)	0.05 Deg/ Pulse	69 Deg/Lb	0.014 Deg/ Pulse	23 Deg/Lb
	3) Radial Jet ΔV Pair with Thrust Offset from Center of Mass	Pulse (128)	0.018 Deg/ Pulse	12 Deg/Lb	0.005 Deg/ Pulse	4 Deg/Lb
Spin Speed	1) Radial Jet Spinup or Despin Pair	Continuous	0.11 RPM/ Sec	9.5 RPM/ Lb	0.1 RPM/ Sec	11.4 RPM/ Lb
	2) Single Radial Jet Spinup or Despin Thruster	Continuous	0.06 RPM/ Sec	9.5 RPM/ Lb	0.05 RPM/ Sec	11.4 RPM/ Lb
Velocity	1) Single Axial Jet	Continuous	0.006 MPS/ Sec	1.2 MPS/ Lb	0.008 MPS/ Sec	1.9 MPS/ Lb
	2) Radial Jet ΔV Pair	(a) Pulse (512)	0.006 MPS/ Pulse	1.07 MPS/ Lb	--	--
		(b) Pulse (128)	--	--	0.002 MPS/ Pulse	1.71 MPS/ Lb

TABLE 4.3.1.4.2-1

ERROR COEFFICIENTS

Error Source (Input) \ Uncertainty (Output)	$\delta\phi_F$	ϵ_F
$\delta\phi_I$	e_1 1	f_1 $\tan\Psi\left(1 - \frac{\sin\phi_F}{\sin\phi_I}\right)$
ϵ_I	e_2 0	f_2 $\frac{\sin\phi_F}{\sin\phi_I}$
$\delta\Psi$	e_3 $P\sin\Psi$	f_3 $\frac{1}{\cos\Psi}\left(\frac{\Delta\theta\sin\phi_F}{\sin\Psi} + P\sin^2\Psi\right)$
δP	e_4 $-\cos\Psi$	f_4 $-\sin\Psi$

TABLE 4.3.1.4.3-1

SPACECRAFT CONFIGURATIONS FOR A TYPICAL PRECESSION MANEUVER

Time Relative to Maneuver / Equipment	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Earth Station(s) in Use:	26 M.	64 M.			
Communications S/S: Mod Index (Radians)	1.18 (Omni; Lo XMTR pwr; 26 M DSN).	0.65 (Fwd Omni; Hi pwr, 64 M DSN)			
Transmit Antenna	Fwd Omni.				
Receive Antenna	Rcvr 1 to Fwd Omni; Rcvr 2 to Aft Omni.				
Exciter	1 ON; 2 OFF. Coherent Mode Enabled.				
Power Amplifier(s)	1 ON; 2, 3, & 4 OFF. (= Low Power).	1 & 3 ON; 2 & 4 OFF. (=Hi Pwr)			
States of Transfer Switches	1 Low pwr to Fwd Omni/Horn. 2 Fwd Omni selected. 3 Exciter 1 selected. 4 AMP 1 to Low. 5 Rcvr Norm Select. 6 AMP 3 Selected.	1 Hi pwr to Fwd Omni/Horn. 4 Amp 1 to Hi.			
Controls S/S: Star Sensor Channels:	• ψ_1* & ψ_2* both ON. • BP & Threshold settings: as req'd.				

[1*]Only the changes from the preceding column are shown.

TABLE 4.3.1.4.3-1. (Continued)

Equipment	Time Relative to Maneuver	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Controls S/S (Cont'd) Sun Sensors		Mid-Range Selected	If final spin axis att. is $\geq 30^{o}$ off norm., then appropriate extend. sun sensor should be selected prior to jet firing.			
Attitude Data Processor	ON/OFF State	ADP 1 ON.				
	Measurement Select	A & B Channels in any configuration.	Configure for spin rate & sun aspect angle measurements: A: ψ to ψ B: ψ to ψ_2			
	Jet Control	1 All Jets Disabled. 2 Spin rate detector enabled. (Cont'd)	1 Preferred: (A5 & A6 select) or A5 selected, or A6 selected; or Backup Mode Choices: (B1 & B2 select) or (B3 & B4 select) or (B1 & B4 select) or (B2 & B3 select)			Same as Column 1.

1* Only the changes from the preceding column are shown.

TABLE 4.3.1.4.3-1 (Continued)

Equipment	Time Relative to Maneuver	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Controls S/S (Cont'd)						
	Jet Control (Cont'd)	3 All other choices: DNA.	3 Pulse fire; pulse count; 128 ms pulse width; normal fire mode - all selected.[1**]			
Attitude Data Processor	ADP Mode Select.	1 SRR Advance Inhibited 2 Sun Gate enabled. 3 Normal (Gate A = 11.25° wide) selected; SRR selected; sun selected; 4 Star Gates A & B: Channel 1 (ψ/*) selected. 5 PLL Loss of Lock enabled. 6 PLL Spin range of 8.0 - 17.7 rpm selected.				
	ADP Configure Commands 3 Through 11	1 Jet countdown: All Zeros. (Continued)	1 Jet countdown magnitude & ACS angle delay magnitude both loaded.	1 Jet countdown magnitude decreasing by one per S/C revolution.	1 Jet countdown magnitude at all binary ones (decimal 4095), & no longer changing.	Same as Column 1.

[1*] Only the changes from the preceding column are shown.

[1**] For Large Precession Maneuvers, the time count mode will be used.

TABLE 4.3.1.4.3-1 (Continued)

Equipment / Time Relative to Maneuver	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Controls S/S (Cont'd)					
Attitude Data Processor (Cont'd): ADP Configure Commands 3 Through 11 (Continued)	(2) ACS Angle: Delay magnitude as required, if Star Gate B is in use. (3) Roll Index Delay magnitude as required. (4) PLL Spin period magnitude - same as prevailing spin period. (5) JCE buffer output disabled.	(2) JCE buffer enabled. (3) Fire interlock then fire.		(2) JCE buffer disabled at fixed time delay relative to 1st pulse firing. (This is backup turnoff of jets. Normal turnoff of jets occurs when JCE countdown register counts down to all zero & cycles once to all ones).	
Attitude Data Processor (Cont'd): Spin Rate	15 rpm.				
Command S/S: Command Processor	(1) 1 & 2 ON. (2) Receiver normal select. (3) SCL 1 & 2 cleared.				
Command Output Modules	1 Through 6 ON.				
Pyrotechnics	PCU Disarmed.				

1* Only the changes from the preceding column are shown.

TABLE 4.3.1.4.3-1 (Continued)

Time Relative to Maneuver / Equipment	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Data Handling S/S :					
Nominal Bit Rate (bps)	At highest supportable bit rate via Fwd Omni and 26 M DSN.	To highest supportable bit rate via Fwd Omni & 64 M DSN.			
Data Format	Bus Engineering	ACS			Bus Engineering.
PCM Encoder	1 ON; 2 OFF				
TM Processor	1 ON/2 OFF. Subcarrier convolutional encoder & data all ON.				
Data Input Modules	All 8 ON.				
Power S/S : Batteries D.O.D.	0%.				
Batteries Charge/Discharge State (typical)	1 Low charge rate selected. 2 Primary discharge reg. selected.				
Protective Circuits	1 All 5 limiters enabled. 2 UV/OL protection ON. 3 Precharge OFF.				
Science Bus	All Loads OFF.				

1* Only the changes from the preceding column are shown.

TABLE 4.3.1.4.3-1 (Continued)

Time Relative to Maneuver / Equipment	Assumed Steady-State (Pre-Maneuver)	Just Prior to First Jet Fire[1*]	Between First Jet Fire & Last Jet Fire[1*]	Immediately After Last Jet Fire[1*]	Assumed Steady-State (Post-Maneuver)[1*]
Propulsion S/S :					
Latch Valves	1 & 2 Closed.	1 &/or 2 Opened as required.			Both closed.
Heaters	Primary tanks, forward and Aft Jet Heaters all ON.				

[1*] Only the changes from the preceding column are shown.

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TABLE 4.3.1.4.3-2

TYPICAL PRECESSION SEQUENCE

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
1	Typical In-Transit Precession from Ecliptic Normal A'' tude. • Determine up-to-date pre-maneuver S/C attitude, spin rate, & velocity for use in determining required precession magnitude & for comparison to post-maneuver values for performance evaluation.		
2	• Via an offline computer program, the up-to-date lbit(s) for the selected thruster(s), the ACS angle delay magnitude required for correct spin axis precession direction (including biases for sun sensor reference pulse & engines thrust vectors), & number of thruster(s) pulses (jet countdown magnitude) required to complete the precession shall be calculated. • An offline computer progr m may also be used to predict the expected cross-coupling errors in spin rate & ΔV resulting from the planned maneuver.		Input data and calculated data: Fuel usage to date (i.e., remaining fuel); tanks pressure; tanks temperatures; prelaunch test data for pulse firing of engines; updated S/C moments of inertia; updated engines moment arms; present S/C attitude in inertial space; total impulse required to change S/C attitude to desired orientation.
3	• Configure for spin rate & sun L.O.S. measurements throughout the impending maneuver:		
ATQØ1: MEA1-SRR; MEA2 S2S (PS12).	ADP1 configure - measurement select.	AM1ADS	Measurement A address: SRR to SRR.
		AM2ADS	Measurement B address: SRR to PS12.
4	• Based on latest measured spin period, update PLL spin period magnitude (below):		Update is recommended if on-board loaded magnitude differs from measured true magnitude by more than $\pm$1 bit ($\pm$0.25 m.s.).

Table 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
4A ATQØ7 (or ATQ78, which is combination of ATQØ7 & ATQØ8 (see ahead)	<u>Typical In-Transit Precession from Ecliptic Normal Attitude (Cont'd)</u> ADP1 Configure - PLL Spin period magnitude (Eight MSBs)		MSBs values of AM1ADS (measured spin period) are commanded here for potential simulated SRR use during ensuing pulse firing.
		ASIMSZ (word 9)	Corresponds to that value commanded.
4B ATQØ8 SIMSPNPDLSB	ADP1 Configure - PLL Spin period magnitude (Eight LSBs)		LSBs value of AM1ADS (measured spin period) here for potential simulated SRR use during ensuing pulse firing.
		ASIMSZ (word 10)	Corresponds to that value commanded
5	• Configure S/C for jet firing short of JCE buffer enable & opening of latch valve(s):		
5A ATQØ2; RnE, RnD, AmE, AmD, as required (n=1 thru 4; m=5 thru 7); FMN; P, 8; CP; FP;SRDE.	ADP Configure - Jet Control ([<u>Preferred</u>: (A5 & A6 selected) <u>or</u> (A5 selected) <u>or</u> (A6 selected)] <u>OR</u> [<u>Backup Mode</u> Choices: (R1 & R2 Selected) <u>or</u> (R3 & R4 selected) <u>or</u> (R1 & R4 selected) <u>or</u> (R2 & R3 selected)] ; normal fire mode, 128 ms pulse width, pulse count, pulse fire, and spin rate detector enabled - all selected.	AJET1S Through AJET8S	= 1 for selected jets; = 0 for remaining jets.
		ASDET3	= 1 (spin rate detector enabled)
		AJETMS (word 2)	= 0 (Pulse fire selected)
		AMAGCS	= 1 (pulse count)
		APULLS	= 0 (128 ms. pulse width)
		AJETMS (word 3)	1 (normal fire select)

Table 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
5B	<u>Typical In-Transit Precession from Ecliptic Normal Attitude (Cont'd)</u>		
ATQØ4 MAGSEC	ADP1 Configure - Jet countdown. (load number of pulses to be fired)	AJMAGC	JCE countdown - magnitude corresponds to that value commanded
6C ATQØ5 ACSANG	ADP1 Configure - ACS angle delay magnitude (azimuthal angle delay between occurance of sun reference pulse and initiation of one pulse firing per spin period).		<u>Notes</u>: (1) Each pulse firing of the total number of pulses loaded above will occur at this constant delay. A large precession may warrant two or more blocks of pulses, each block having a unique angle delay magnitude for all of its pulses. (2) There is a one count bias, i.e., the actual delay is one count greater than the commanded value.
6	• Verify ADP mode telemetry is as indicated at the right:	ADVANS	= 0 (SRR advance inhibited).
		ASUNGS	= 1 (sun gate enabled)
		A*ACQS	= 0 (normal)
		ASRRMS (Bit 6)	= 1 (SRR selected)
		ASRCMS (Bit 5)	= 1 (sun selected)
		ASUNSS	Sun Sensor: Midrange selected. (Assuming precession magnitude ≤60°)
		A*GASS	Star Gate A = 1 (channel 1 selected)
		A*GBSS	Star Gate B = 1 (channel 1 selected)
		ALOLES	PLL Loss of lock = 1 (enabled)
		ASPINS	PLL Spin range select: 8.0-17.7 RPM

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
7	<u>Typical In-Transit Precession from Ecliptic Normal Attitude</u> (cont'd) o Verify JCE buffer is disabled before proceeding:	AJCEFS	= 0 (JCE fire disabled).
8	o Transfer command control to 64 M DSN Station. Tune up-link frequency to produce phase-locked downlink corresponding to rest frequency of VCO in Receiver 1.		
9	o Configure downlink for HI transmitter power and Fwd Omni usage:		
9A AMP1Ø or AMPAØ	Power Amplifiers 1 and 2 OFF. o Verify loss of downlink before proceeding.		Loss of Downlink Carrier.
9B ANT12 or ANTA2	High Power to Fwd Omni/Horn Select.		No downlink - not verifiable in real time.
9C AMP12 or AMPA2	Amplifier 1 to High Power Select		No downlink - not verifiable in real time.
9D AMP12 or AMPA9	PA 1 ON/2 OFF.		Carrier may be detectable at multiple of rest frequency of VCO in receiver 1 (should be phase-locked).
9E AMP39 or AMPC9	PA 3 ON/4 OFF.		Sufficient downlink should be present for gnd receiver lock on the carrier demod sync with the subcarrier; & bit sync on the data. Frame sync will follow later because of the low bit rate.

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
10	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd) • Change bit rate to highest supportable via fwd omni, HI Xmtr power, and 64 M. DSN. Station usage (worst case of 16 bps assumed ahead):		
10A MILTI or MILA1	Low Mod Index Select.		Momentary disruption in data in worst case - likely demod sync, bit sync, and frame sync will be retained as carrier suppression is decreased by 6.4 dB.
10B TPCQI or TPCQA	Telemetry processing control - bit rate select (to 16 bps).	Bit Rate Selection	Indicates 16 bps.
11	• Verify COMM S/S Telemetry Status before proceeding.	RANT1S	High/Low Power to Fwd or Horn/Aft Omni Status = 0 (HI Power to Fwd or Horn).
		RAMP1S	AMP1/2 to HI/LO pwr = 1 (AMP 1 to HI).
		RANT2S	Forward Omni/Horn Switch Pos. = 1 (Forward Omni Selected).
		RAMP1T	PA 1 temperature settles at "ON" level.
		RAMP1W	RF Power output 1 = 9.5 Watts (Nom.).
		RAMP3T	PA 3 temperature rises & settles at "ON" level.
		RAMP3W	RF power output 3 = 9.5 Watts (Nom.).
		RAMP3S	Amplifier 3/4 Switch Position = 1 (Amplifier 3 Selected)

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
12	<u>Typical In-Transit Precession from Ecliptic Normal Attitude</u> (cont'd) • To produce higher sampling of pertinent data during the maneuver, switch to the ACS Format:		
TPCQ1 <u>or</u> TPCQA	Telemetry processor control - format select (to ACS Format).		• Loss of frame sync. • If 3 successive minor frames are required to re-establish frame sync, then 96 seconds (worst case) will elapse before it occurs, due to 16 bps rate.
13	• According to the selected thruster(s), open the pertinent latch valves:		
13A VAL19 <u>or</u> VALA9	Latch Valve 1 Open (if required - for use of any combination of R3, R4 or A5).	VALV1S	Latch Valve 1 Open/Closed = 1 (Open).
13B VAL29 <u>or</u> VALB9	Latch Valve 2 Open (if required - for use of any combination of R1, R2 or A6).	VALV2S	Latch Valve 2 Open/Closed = 1 (Open).
14	• Verify proper latch valve status before proceeding.		
ATQ09	ADP 1 Configure - JCE Buffer Output Enable.	AJCE1S	JCE Buffer = 1 (Enabled).
15	• Verify that Buffer is enabled before proceeding.		
ATQ11	ADP 1 Configure - Jet Fire Interlock.		
16	• Immediately after executing the following Jet Fire command, monitor the indicated telemetry data. As ground backup to the onboard system, be ready to execute the JCE buffer output disable command (abend), if telemetry indicates a significant deviation from expected values.		The S/C is protected against erratic performance by: 1. PLL Loss of Lock enabled (two successive out-of-lock occurrances terminates the maneuver). (Continued)

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
16 (Continued)	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd)		2. Spin rate detector enabled (if spin rate exceeds the range 3.7 to 67 rpm - the maneuver is terminated). 3. On-board automatic firing duty cycle detector (if firing duration per spin period exceeds 28% for certain, & exceeds 13% possibly, the maneuver is terminated). 4. Jet countdown circuit. (After the number of pulses loaded in the countdown circuit are fired, JCE buffer and JCE fire enable latch (latter enabled in next step) are both automatically disabled).
ATQ12	ADP 1 Configure - Jet Fire.	AJCEFS	JCE Fire Enable 1 (firing). Remains 1 only for firing duration, i.e., during pulse firing, likely it will telemeter as zero.
		VJET1T	Radial Jet 1 Temp. } Increase for each thruster previously selected.
		VJET2T	Radial Jet 2 Temp.
		VJET3T	Radial Jet 3 Temp.
		VJET4T	Radial Jet 4 Temp.
		VJET5T	Fwd Axial Jet 5 Temp.
		VJET6T	Aft Axial Jet 6 Temp.
		VTANKP	Tank Pressure - may show a detectable gradual change, depending on magnitude of precession.

(Continued)

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
ATQ12 (Cont'd)	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd)	PLIMTI	Bus Voltage Limiter Current
		PBUSLI	S/C Loads Current
			If telemetry sampling of either of these occurs during a jet firing, a change will be seen (increase for PLIMTI; decrease for PBUSLI). (With use of ACS format & 16 bps, PBUSLI is telemetered once every 16 sec.; PLIMTI, once every 2048 secs. With firing occurring for a 128 Msec, duration once every 4 sec. probability of a change being detected is very low).
		AM2ADS/ ATTM1Z	SRR to PSI2 - Changes as expected (increase or decrease), and at expected rate.
		AM1ADS/ ATTM1Z	SRR to SRR - Changes as expected (spin rate) - based on estimated misalignments of thrusters.
		ALOCKS	PLL Loss of Lock = 1 (no loss of lock): If PLL loss of lock has been enabled, a loss of the roll reference pulse for two successive S/C revolutions (and not before) will cause this to drop to zero and terminate the maneuver. If PLL loss of lock has been inhibited, this will stay at "1" at all times.
		AJMAGC	JCE Countdown - Decreases by one count per spin period.

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd)		
17	o If a problem occurs during firing, send the next command immediately. Otherwise, send it after a time delay from the previous jet fire command so as to be executed onboard immed-lately after the last pulse firing has occurred.		
ATQ1Ø	ADP 1 Configure - JCE Buffer Output Disable.	AJCE1S	JCE Buffer = 0 (disabled)
18	o Verify completion of firing via the telemetry indication at the right.	AJMAGC	JCE Countdown has counted down to all zeros, then counter has recycled to all binary ones (decimal 4096) and stopped changing.
		AJCEFS	JCE Fire Enabled = 0 (Not firing).
		AM2ADS/ ATTM1Z	SRR to PSI2 - No change since termination of firing.
		AM1ADS/ ATTM1Z	SRR to SRR - No change since termination of firing.
		AJCE1S	JCE Buffer = 0 (disabled).
19	o Begin trajectory determination to establish ΔV caused by precession.		
20	o Reconfigure the S/C for post-maneuver steady-state operations (assumes no subsequent imminent maneuver operations):		
20A VAL1Ø or VALAØ	Latch Valve 1 Closed (if open).	VALV1S	Latch Valve 1 Open/Closed = 0 (closed).
20B VAL2Ø or VALBØ	Latch Valve 2 Closed (if open).	VALV2S	Latch Valve 2 Open/Closed = 0 (closed).

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd)		
20C ATQØ2 RnD & AmD (n = 1 thru 4; m = 5 thru 7); FMN; P/8; CP;FP; SRDE.	ADP 1 Configure - Jet Control (all Jets disabled).	AJET1S through AJET6S	= 0 for all Jets.
		ASDETS	= 1 (spin rate detector enabled)
		AJETMS	Continuous/pulse fire select = 0 (pulse).
		AMAGCS	Pulse/time count select = 0 (Time).
		APULLS	Pulse Width Select = 0 (128 ms).
		AJETMS (Word 3)	Normal/Alternate Fire Mode = 1 (Normal)
20D ATQØ4	ADP 1 Configure - Jet Countdown (= All zeros).	AJMAGC	JCE Countdown = Magnitude of all zeros.
20E ATQØ7 (or ATQ78, which is combination of ATQØ7 & ATQØ8 (see ahead).	ADP 1 Configure - PLL Spin Period Magnitude (MSBs).		MSBs values of AM1ADS (measured spin period) are commanded here for potential simulated SRR use.
		ASIMSZ (Word 9)	Corresponds to that value commanded.
20F ATQØ8	ADP 1 Configure - PLL Spin Period Magnitude - (LSBs)		LSBs value of AM1ADS (measured spin period) are commanded here for potential simulated SRR use.
		ASIMSZ (Word 10)	Corresponds to that value commanded.

TABLE 4.3.1.4.3-2 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
21	Typical In-Transit Precession from Ecliptic Normal Attitude (cont'd) o Stay in the ACS Format while performing an attitude determination (refer to Section 4.3.2) then return to engineering format:		
TPCQ1 or TPCQA	Telemetry Processor Control - Format select (to Engineering Format).		o Loss of frame sync. o If 3 successive minor frames are required to re-establish frame sync, then 96 seconds (worst case) will elapse before it occurs, due to 16 bps rate.
22	o Resume steady-state operations as defined in Table 4.3.1.4.3-1 Monitor batteries states-of-charges and comm. S/S temperatures in face of HI XMTR Power Operation.		

TABLE 4.3.2.2-1

REPRESENTATIVE VALUES FOR ATTITUDE DETERMINATION ERROR CONTRIBUTIONS

(EXCLUDES TRAJECTORY ERRORS)

Bias Error Source	Via ψ - ψ Measurement:		Via ψ to ψ* or ψ2* Measurements	
	Midrange (Deg)	Extended Range (Deg)	Midrange (Deg)	Extended Range (Deg)
Sensor Alignment Uncertainty	0.009	0.027	0.061	0.071
S/C Structural Deformation	0.086	0.268	0.171	0.400
Calibration Uncertainty	0.105	0.255	0.085	0.135
Leading Edge Uncertainty (Note 1)	0.1	0.1	0.244	0.331
Threshold Detection Error	0.052	0.052	0.037	0.037
Spacecraft Wobble (0.2°)	0.140	0.535	0.176	0.754
ΣRSS	0.225	0.661	0.363	0.929
Random Errors				
Jitter (All Sources)	0.148	0.148	0.376	0.387
Nutation (0.1°)	0.070	0.268	0.088	0.377
ΣRSS	0.164	0.306	0.387	0.540
Total Error (Bias + Random)	0.389	0.967	0.750	1.469

NOTES:

(1) Assumes compensation for sun size variation per Figure 3.3.2.1-5.

(2) Worst Case Values are assumed for all components determined for the following separate conditions (any system condition would produce less values, since some of the separate conditions cannot occur simultaneously):

- Sun is at edge of FOV of each sensor.
- 5 RPM for jitter determination.
- 60 RPM for fixed time errors (i.e., biases plus random errors).
- Maximum wobble and nutation angle as specified in PC-410.

TABLE 4.3.2.3-1

BASIC SCHEMES FOR ATTITUDE DETERMINATION

Scheme	Data Types	Sensors Required	Minimum No. of Visible Stars Required	Minimum No. of Measurements Required
1 <u>Dual Slit</u>: Sun angle + Star angle	$\psi\psi_2$, $\psi^*(i)\ \psi_2^*(i)$	Sun, ψ^* slit, ψ_2^* slit.	1	2
2 <u>Single Slit</u>: Sun Angle + Sun to Star Roll Angle with one Star Sensor Slit	$\psi\psi_2$, $\psi\psi^*(i)$ or $\psi\psi_2^*(i)$	Sun, ψ^* Slit or ψ_2^* Slit	1	2
3 <u>Mapping</u>: Two Spin Angles Between Three Targets	$\psi\psi^*(i)$, $\psi\psi^*(j)$ or $\psi\psi_2^*(i)$, $\psi\psi_2^*(j)$	Sun Sensor, one star slit.	2	2
	OR	OR		
	$\psi^*(i)\psi^*(j)$ or $\psi_2^*(i)\ \psi_2^*(j)$	One Star Sensor Slit	3	
	OR	OR		
	$\psi^*(i)\ \psi_2^*(j)$	Two Star Sensor Slits		

TABLE 4.3.2.3-2

RELATIVE MERITS OF ATTITUDE DETERMINATION SCHEMES

Scheme	Advantages	Disadvantages
1 Dual Slit	• Uses Sun Angle. • Requires one star. • Good Accuracy for Star/Sun relative longitude >30°.	• Susceptible to Bias Errors at low sun angles (w.r.t. +Z axis) • Uses Star as roll reference. • Requires both Star Sensor Slits • Poor Accuracy for Star Opposite Sun.
2 Single Slit	• Uses Sun Angle. • Uses sun as roll reference. • Requires one star. • Requires one star sensor slit. • Good accuracy for star opposite sun.	• Susceptible to bias errors at low sun angle (w.r.t. +Z axis). • Poor accuracy for star/sun relative longitude 60° to 120°.
3 Mapping	• Can use sun as roll reference. • Can use one star sensor slit. • Three targets relax accuracy dependence on relative longitude between targets.	• Requires at least two stars. • Requires gating on at least two stars. • Two or more stars must satisfy interference criteria.

TABLE 4.3.2.3-3

BASIC SCHEMES FOR ATTITUDE ESTIMATION

Scheme	Data Types	Sensors Required	Min. No. of Visible Stars Req'd.	Min. No. of Meas. Req'd.	Biases Estimated
1 Sun Angle + sun-to-star angles with star sensor slits.	$\psi\psi_2$, $\psi\psi^*(i)$, $\psi\psi_2^*(i)$	Sun, ψ^* slit, ψ_2^* slit.	3	7	• Relative azimuth of ψ/ψ^*, ψ/ψ_2^*. • Relative cant of ψ/ψ^*, ψ/ψ_2^*. • Relative azimuth of ψ/ψ_2 or relative cant of ψ/ψ_2.
2 Sun angle + sun-to-star roll angles with one star sensor slit.	$\psi\psi_2$, $\psi\psi^*(i)$ or $\psi\psi_2^*(i)$	Sun, ψ^* or ψ_2^* slit.	4	5	• Relative azimuth of ψ/ψ^* or ψ/ψ_2^* • Relative cant of ψ/ψ^* or ψ/ψ_2^*. • Relative azimuth of ψ/ψ_2 or relative cant of ψ/ψ_2.
3 Star-to-star roll angles with two star sensor slits.	$\psi^*(i)\ \psi_2^*(j)$ $i = j$ AND/OR $i \neq j$	ψ^* slit, ψ_2^* slit.	4	4	• Relative azimuth of ψ^*/ψ_2^*. • Relative cant of ψ^*/ψ_2^*.
4 Star-to-star roll angles with one star sensor slit.	$\psi^*(i)\ \psi^*(j)$ or $\psi_2^*(i)\ \psi_2^*(j)$ $i \neq j$	ψ^* or ψ_2^* slit.	4	3	• Cant of ψ^* or ψ_2^* with respect to spin plane.

TABLE 4.3.2.3-4

RELATIVE MERITS OF ATTITUDE ESTIMATION SCHEMES

Scheme	Advantages	Disadvantages
1 Sun angle + Sun to Star roll angles with both slits.	• Uses sun as roll reference. • Requires least number of Stars (3). • Biases estimated from any other scheme can be derived. • Done periodically; then one star/any slit useful.	• Requires most measurements (7).
2 Sun angle + Sun to Star roll angles with one slit.	• Uses sun as roll reference. • Requires one slit. • Done periodically; then one star/one slit useful.	• Requires 4 stars. • Requires 5 measurements. • Requires use of particular slit whose biases have been estimated.
3 Star to Star roll angles with two slits.	• Independent of Sun. • Can infer one sun sensor bias; however, this requires 5 measurements.	• Uses star as roll reference. • Requires 4 Stars. • Minimum of 2 stars are required for deterministic solution subsequently.
4 Star to Star roll angles with one slit.	• Independent of Sun. • Minimum number of measurements (3). • One sun sensor bias can be inferred from $\psi\psi_2$ data Requires 4 measurements.	• Uses star as roll reference. • Requires 4 stars. • Minimum of 3 stars are required for deterministic solution subsequently.

TABLE 4.3.2.3-5

EXPECTED ATTITUDE ESTIMATION ACCURACY FOR SOME MISSION EVENTS

Event Start Time	Event	Action	Remarks	Estimation Accuracy (Stars/Slits Available) 3/2	4/1	2/2	3/1
L+5 Hr (≈1 Hr after initial ground station acquisition) L Launch Time.	Cruise.	1) First "quick-look" att. det. w.r.t. sun l.o.s. 2) Bias estimation using available stars.	• Average sun look angle nominally ≈ 90° near south ecliptic normal attitude.			0.06 to 0.26	0.06 to 0.34
E-28 Days E - Venus Encounter.	Post Reor into Ecliptic Plane.	1) "Quick Look" Att. Det. w.r.t. sun l.o.s. 2) Bias estimation using available stars.	• Sun angle ≈ 51° • Initial look at biases of upper sun sensor.			0.01 to 0.5	0.01 to 0.6
E-24 Days	Large Probe Separation.	1) Reorient spin axis. 2) Quick-look at sun angle. 3) Map available stars for att. det. 4) Touchup Reor. 5) Separation.	• Sun angle ≈34°. • Useful to obtain data after Large Probe release for estimation of biases with new wobble.			0.06 to 0.38	0.01
E-23 Days	Small Probe Targeting.	1) Reorient spin axis. 2) Quick-look at sun angle. 3) Map available stars for att. det. 4) Touchup reor. 5) Spin up to 48.5 rpm + Rad jet maneuver.	• Sun angle ≈45°. • Continue data taking for bias estimation.			0.06 to 0.48	0.02 to 0.28
E-20 Days	Small Probe Separation.	1) Reorient Spin Axis. 2) Quick-look at sun angle. 3) Map available stars for att. det. 4) Second Part of Precession. 5) Attitude Determination. 6) Separation.	• Sun angle ~17°. • Previous calibrations would permit use of 2/1 or 1/2 to define attitude to <1°.			0.05	--

TABLE 4.3.2.4-1

MEASUREMENTS OF S/C ATTITUDE TELEMETERED DATA TYPES

(NOTE: All sequences assume that the SRR has already been established per Section 4.3.3)

Measure: To : From (established SRR) :	PSI	PSI2	P [illegible]*	PSI2*
PSI	• Produces spin period • Part of sequence in Table 4.3.2.4-2	• Perform sequence in Table 4.3.2.4-2	• Perform sequence in Table 4.3.2.4-3	• Perform sequence in Table 4.3.2.4-4
PSI*	Not possible for S/C design	• Perform sequence in Table 4.3.2.4-2	• For the same star, produces spin period • For different stars, perform sequence in Table 4.3.2.4-5	• Perform the sequence in Table 4.3.2.4-6
PSI2*	Not possible for S/C design	• Perform sequence in Table 4.3.2.4-[illegible]	• Perform the sequence in Table 4.3.2.4-6	• For the same star, produces spin period • For different stars, perform sequence in Table 4.3.2.4-5

TABLE 4.3.2.4-2
MEASUREMENT OF SUN ASPECT (ELEVATION) ANGLE ($\psi\ \psi_2$ OR $\psi_2*\ \psi_2$ OR $\psi*\ \psi_2$)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
1	• Given the initial spacecraft configuration shown in the first column of Table 4.3.1.4.3-1, use the existing SRR, which is assumed to be either the sun or a known star.		
2	• If not already so, configure ADP measurements to obtain data for calculation of sun elevation angle:		
ATQØ1 (For ADP1 Only) (MEA1 = SRR, MEA2 S2S)	ADP1 Configure - Measurement Select ((SRR to SRR) and (SRR to PS(2)).	AM1ADS	Measurement A Address: (SRR to SRR)
		AM2ADS	Measurement B Address: (SRR to PS12)
		ATTM1Z OR ATTM2Z	Measurement Data: Reflects above data according to:
		ATTMSS	Data Measurement = 1 (A) or = 0 (B), alternating no more often than once per spin period, as explained in Section 3.3.2.3.6 and 3.3.3.5.

TABLE 4.3.2.4-2. (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
3	• Accumulate at least 30 valid samples of each measurement. Accept as a valid sample: (1) Only the first ATTM1Z or ATTM2Z sample following a <u>change</u> in ATTMSS. (2) Only samples accompanied by the indicated telemetry at the right:		
		ALOCKS	PLL Loss of Lock = 1 (no loss of lock)
		AMISSC	Missed SRR Count = <u>No</u> change from last sample of this parameter.
		ALOLES	PLL Loss of Lock = 1 (Enabled } Not required but preferred
		ASUNGS	Sun Gate = 1 (Enabled) if the Sun is the SRR. } Not required but preferred
4	• Determine the mean of each set of 30 samples - Reject samples outside of 3σ deviation from the mean and recalculate the mean of the remaining samples.		
5	• Calculate "spin angle" for SRR to Sun: $AZEL_{SUN}$ = (Mean of (SRR to ψ_2) samples) ÷ (Mean of (SRR to SRR) samples) - $BIAS_{ELSUN}$, where $BIAS_{ELSUN}$ = value obtained from Table in "Remarks" column.		SRR: Corresponding value from Tables 3.3.2.2.6-1 & 3.3.2.2.6-2 for $BIAS_{ELSUN}$
			PSI: Zero.
			PSI*: -(1)-(2)-(3)+(A)+(B)+(C).
			PSI2*: -(1)-(2)-(3)+(A)+(C).

TABLE 4.3.2.4-2 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
6	• If the SRR is PSI, declare EL_{SUN} = $AZEL_{SUN}$ and proceed to the next step. • If the SRR is PSI* or PSI2*, then calculate: $\theta = AZEL_{SUN} - SEP_{STARSUN}$, where $SEP_{STARSUN}$ = Azimuthal separation angle from the SRR star to the sun, measured in the plane normal to the S/C spin axis (measured in direction of spin). • If $\theta < 0^{\circ}$, then $EL_{SUN} = 360^{\circ} + \theta$ • If $\theta \geq 0^{\circ}$, then $EL_{SUN} = \theta$		
7	• Use any one of the following to determine the sun aspect (elevation) angle (approximate) w.r.t. the S/C spin axis, using the value EL_{SUN} as the known spin angle delay: (1) The appropriate equation in Figure -1 or Figure 3.3.2.1-2. OR (2) The appropriate curve in Figure 3.3.2.1-5. OR (3) Any applicable nomogram - or table, when assembled, in the PV Telemetry Data Conversion Handbook (Reference Para. 1.5.17).		

TABLE 4.3.2.4-3

MEASUREMENT OF SUN TO STAR USING THE PSI* SLIT ($\psi\psi^*$)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
	Because a spin angle measurement using the PSI* slit is dependent on the elevation of a star, as seen in Figures 3.3.2.2-3A and 3.3.2.2-3B, determination of the roll (azimuth) angle to a star requires use of the PSI2* slit as well as the PSI* slit. Once spin angle measurements to the star using both slits are made, the roll (azimuth) and aspect (elevation) angles to the star may be determined concurrently. The following sequence details the first basic step in this procedure and references the reader to the final basic step.		
1	o Given the initial spacecraft configuration shown in the first column of Table 4.3.1.4.3-1, use the existing SRR, which is assumed to be the sun.		
2	Configure the PSI* and PSI2* channels for the measurement star:		
STRQ1 OR STRQA	Star Sensor Threshold and Bandpass Select. (Both channels set to threshold setting and bandpass compatible with the measurement star.	A*1THS	PSI* Threshold Setting — All Conform to Commanded State
		A*2THS	PSI2* Threshold Setting — All Conform to Commanded State
		A*1BPS	PSI* Bandpass State — All Conform to Commanded State
		A*2BPS	PSI2* Bandpass State
3	Assign PSI* Channel to Star Gate B:		
ATQØ3 (For ADP1 Only) (SGB = 1)	ADP 1 Configure - ADP Mode Select (Star Gate B = Channel 1 (PSI*); All other ADP Mode States unchanged).	A*GBSS	Star Gate B = 1 (= Channel 1 = PSI*)
4	Locate Star Gate B over the measurement Star:		

TABLE 4.3.2.1-3 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
ATQ05 (For ADP1 Only) (ACSANG = XXX.XX)	ADP1 Configure - ACS Angle Delay Magnitude (Calculate θ = $SEP_{SUNSTAR}$ - $BIAS_{PSIPSI*}$ - 0.352° -5.625° (to locate star in the center of Star Gate B) where $SEP_{SUNSTAR}$ = estimated azimuthal separation angle measured in plane normal to spin axis from the sun l.o.s. to the star l.o.s. (measured in the direction of S/C spin); and $BIAS_{PSIPSI*}$ = Value defined in Remarks column. If θ is positive, then the commanded magnitude θ. If θ is negative, then the commanded magnitude 360° + θ.	AACSAD	ACS Angle Delay Magnitude = (same magnitude as that commanded) • $Bias_{PSIPSI*}$ (values obtained from Tables 3.3.2.2.6-1 & 3.3.2.2.6-2: - (1)-(2)-(3)+(A)+(B) (C). • Actual delay is 0.352° larger than the commanded value.
(5)	Configure ATTM for star data:		
ATQ01 (For ADP1 Only) (MEA1 = SRR, MEA2 GSB)	ADP 1 Configure - Measurement Select (SRR to SRR) and (SRR to Gated Star B).	AM1ADS	Measurement A Address: (SRR to SRR)
		AM2ADS	Measurement B Address: (SRR to Star Gate B)
		ATTM1Z OR ATTM2Z	Measurement Data - Reflects above data according to:
		ATTMSS	Data Measurement = 1(A) or = 0(B), alternating no more often than once per spin period as explained in Sections 3.3.2.3.6 and 3.3.3.5.

TABLE 4.3.2.4-3 (Continued)

Command Mnemonic	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
6	• Accumulate at least 30 valid samples of each measurement. Accept as a valid sample: 1) Only the first ATTMIZ or '2Z sample following a change in ATTMSS. 2) Only samples accompanied by the indicated telemetry at the right:		
		ALOCKS	PLL Loss of Lock = 1(No loss of lock)
		AMISSC	Missed SRR Count = No change from last sample of this parameter.
		ALOLES	PLL Loss of Lock - 1 (Enabled) } not necessary but preferred
		ASUNGS	Sun Gate = 1 (Enabled) } not necessary but preferred
		ASRRMS	Sun/Star Select = 1 (Sun) } not necessary but preferred
7	Determine the mean of each set of 30 samples - reject samples outside of 3σ deviation from the mean; then recalculate the mean of the remaining samples.		
8	Calculate Spin Angle: $AZEI_{STAR}$ = {(Mean of (SRR to Gated Star B) Samples) ÷ (Mean of (SRR to SRR) Samples)} + $BIAS_{PSIPSI}$* The resulting value is dependent on the elevation of the star as well as its azimuthal separation (pure "roll" angle) from the sun. To determine these values, proceed to Table 4.3.2.4-4.		o $BIAS_{PSPSI}$* WAS DEFINED IN Step 4

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TABLE 4.3.2.4-4

MEASUREMENT OF SUN-TO-STAR ASPECT ANGLE ($\psi\psi_2^*$ and $\psi\psi^*$)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
1	o Given the initial spacecraft configuration shown in the first column of Table 4.3.1.4.3-1, use the existing SRR, which is assumed to be the sun.		
2	Configure the PSI* and PSI2* channels for the measurement star.		
STRQI OR STRQA	Star Sensor threshold and bandpass select. (Both channels set to threshold setting and bandpass compatible with the measurement star.	A*1THS	PSI* Threshold Setting All conform to Commanded State.
		A*2THS	PSI2* Threshold Setting
		A*1BPS	PSI* Bandpass State
		A*2BPS	PSI2* Bandpass State
3	Assign PSI2* Channel to Star Gate B:		
ATQØ3 (for ADP1 Only) (SGB = 2)	ADP 1 Configure - ADP Mode select (Star Gate B = Channel 2 (PSI3*); All other ADP Mode States unchanged).	A*GBSS	Star Gate B = 0 (= Channel 2 = PSI2*).
4	Locate Star Gate B over the measurement star.		
ATQØ5 (for ADP1 Only) (ACSANG = XXX.XX)	ADP 1 Configure - ACS Delay Magnitude (Calculate $\theta = SEP_{SUNSTAR} - BIAS_{PSIPSI2*} - 0.352^{\circ} - 5.625^{\circ}$ (to locate star in the center of Star Gate B), where $SEP_{SUNSTAR}$ = Estimated azimuthal separation angle measured in plane normal to spin axis from the sun l.o.s. to the star l.o.s. (measured in the direction of S/C spin); and $BIAS_{PSIPSI2*}$ = value obtained from Remarks column. o If θ is positive, then the commanded magnitude = θ. o If θ is negative, then the commanded magnitude = $360^{\circ} + \theta$.	AACSAD	ACS Angle Delay Magnitude = (same magnitude as that commanded)
			o $BIAS_{PSIPSI2*}$ (values obtained from Tables 3.3.2.2.6-1 & 3.3.2.2.6-2: -(1)-(2)-(3)+(A)+(C).
			o Actual delay is 0.352° larger than the commanded value.

TABLE 4.3.2.4-4 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
5	Configure ATTM for Star Data:		
ATQØ1 (for ADP1 Only) (MEA1 = SRR, MEA2 = SGB)	ADP 1 Configure - Measurement Select (SRR to SRR) and (SRR to Gated Star B).	AM1ADS	Measurement A Address: (SRR to SRR)
		AM2ADS	Measurement B Address: (SRR to Star Gate B).
		ATTM1Z or ATTM2Z	Measurement Data - Reflects above data according to:
		ATTMSS	Data Measurement = 1(A) or = 0(B), alternating no more often than once per spin period as explained in Sections 3.3.2.3.6 and 3.3.3.6.
6	• Accumulate at least 30 valid samples of each measurement. Accept as a valid sample: 1. Only the first ATTM1Z or ATTM2Z sample following change in ATTMSS. 2. Only samples accompanied by the indicated telemetry at the right:	ALOCKS	PLL Loss of Lock = 1 (No loss of lock).
		AMISSC	Missed SRR Count = No change from last sample of this parameter.
		ALOLES	PLL Loss of Lock = 1 (Enabled) — Not Necessary But Preferred.
		ASUNGS	Sun Gate = 1 (Enabled)
		ASRRMS	Sun/Star Select = 1 (Sun)
7	Determine the mean of each set of 30 samples - reject samples outside of 3σ deviation from the mean; then recalculate the mean of the remaining samples.		
8	Calculated biased "spin angle" for sun-to-star: AZELPSI2* = {Mean of (SRR to Gated Star B Samples) $\div$ (Mean of SRR to SRR) Samples)}.		

TABLE 4.3.2.4-4 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
9	• The resulting AZELPSI2* includes an azimuth (roll) component and an elevation (aspect) component for the measurement star, as well as the biases between the PSI slit and the PSI2* slit. • The actual aspect (elevation) angle of the measurement star, measured w.r.t. the S/C spin axis, may be determined as follows: (a) Determine the spin angle delay using the PSI* slit by performing Steps 1 through 7 of the sequence in Table 4.3.2.4-3 (if not already performed). (b) From the mean values determined in Step 7 of Table 4.3.2.4-3, calculate: AZELPSI* = {Mean of (SRR to Gated Star B) Samples} ÷ {Mean of (SRR to SRR) Samples}. (c) Calculate EL_{STAR} = AZELPSI2* - AZELPSI* . (d) Use Figure 3.3.2.2-4A or Figure 3.3.2.2-4B where EL_{STAR} = PSI* to PSI2* spin angle delay in degrees, to obtain elevation angle of the star w.r.t. the S/C spin axis.		
10	The actual roll (azimuth) angle of the measurement star, measured w.r.t. the sun in the spacecraft spin plane and in the direction of positive spacecraft spin, may be determined as follows: The roll (azimuth angle) = AZPSI2* = AZELPSI2* + AZBIAS + EL_{STAR}, where AZBIAS = value obtained from Remarks column.		AZBIAS (values obtained from Tables 3.3.2.2.6-1 & 3.3.2.2.6-2:) -(1)-(2)-(3)+(C).

TABLE 4.3.2.4-5

MEASUREMENT OF STAR "SPIN" ANGLE USING THE SRR STAR CHANNEL ($\psi^*\psi^*$ OR $\psi_2^*\ \psi_2^*$)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
	Because a spin angle measurement using the PSI* slit is dependent on elevation of a star, as seen in Figures 3.3.2.2-3A and 3.3.2.2-3B, determination of the roll (azimuth) angle to a star requires use of the PSI2* slit as well as the PSI* slit. Once spin angle measurements to the star using both slits are made, the roll (azimuth) and aspect (elevation w.r.t. the SRR star) angles to the measurement star may be determined concurrently. The following sequence details the first basic step in this procedure, and references the reader to the final basic step.		
1	• Given the initial spacecraft configuration shown in the first column of Table 4.3.1.4.3-1, use the existing SRR, which is assumed to be a known star (call it the "SRR" Star). • This sequence is to be used only for either one of the following two cases: (1) PSI* is the SRR channel, and PSI* will also be used for Star Gate B. (2) PSI2* is the SRR channel, and PSI2* will also be used for Star Gate B.		
2	• It is undesirable to change the threshold setting and bandpass setting for the star channel that is being used as the SRR channel. This is to prevent loss of the present SRR and subsequent loss of DCE control.		
3	• If not already so, assign the Star channel being used as the SRR channel (i.e., Star Gate A) also to Star Gate B:		
ATQØ3 (for ADP1 Only)	ADP 1 Configure - ADP Mode Select (Star Gate A - Retain present channel selection. Star Gate B - Make the same as for Star Gate A (1 for PSI*; 2 for PSI2*).	A*GASS	Star Gate A - No change in TM reading.
		A*GBSS	Star Gate B = Same as for Star Gate A (= 1 for PSI*, = 0 for PSI2*).

TABLE 4.3.2.4-5 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
(4)	• Locate Star Gate B over the star to be measured (call it the measurement star):		
ATQØ5 (for ADP1 Only) (ACSANG = XXX.XX)	ADP 1 Configure - ACS Angle Delay Magnitude. Calculate θ = SEP_{STARS} - 5.625° (to locate measurement star in the center of Star Gate B) - 0.352°, where SEP_{STARS} = Estimated azimuthal separation angle measured in the plane normal to the spin axis from the SRR star l.o.s. to the measurement star l.o.s. (measured in the direction of S/C spin). • If θ is positive, then the commanded magnitude = θ. • If θ is negative, then the commanded magnitude = 360° + θ.	AACSAD	ACS Angle Delay Magnitude = (Same magnitude as that commanded).
			• Actual delay is 0.352° larger than the commanded value.
(5)	Configure ATTM for Star Data:		
ATQØ1 (for ADP1 Only) (MEA1 = SRR, MEA2 = SGB)	ADP 1 Configure - Measurement Select. (SRR to SRR) and (SRR to Gated Star B).	AM1ADS	Measurement A Address: (SRR to SRR)
		AM2ADS	Measurement B Address: (SRR to Star Gate B)
		ATTM1Z OR ATTM2Z	Measurement Data - Reflects above data according to:
		ATTMSS	Data Measurement = 1(A) or = 0(B), alternating no more often than once per spin period as explained in Sections 3.3.2.3.6 and 3.3.3.5.

TABLE 4.3.2.4-5 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
6	• Accumulate at least 30 valid samples of each measurement. Accept as a valid sample: (1) Only the first ATTM1Z or ATTM2Z sample following a change in ATTMSS. (2) Only samples accompanied by the indicated telemetry at the right.	ALOCKS	PLL Loss of Lock = 1 (No loss of lock)
		AMISSC	Missed SRR Count = No change from last sample of this parameter.
		ALOLES	PLL Loss of Lock = 1 (Enabled) } Not Necessary but Preferred.
		ASRRMS	Sun/Star [illegible] 0 (Star) }
7	Determine the mean of each set of 30 samples - reject samples outside of 3σ deviation from the mean; then recalculate the mean of the remaining samples.		
8	• Calculate "spin angle" from the SRR star to the measurement star: AZELSAME = (Mean of (SRR to measurement star) samples ÷ (Mean of (SRR to SRR) samples).		
9	• The resulting value is dependent on the elevation of the measurement star, its azimuthal separation (pure "roll" angle) from the SRR star, and the (known) elevation angle of the SRR star. To determine these values, proceed to Table 4.3.2.4-6. If the PSI* slit was used for the SRR in this sequence, then perform the PSI* to PSI2* measurement in Table 4.3.8.4-6. Otherwise, perform the PSI2* to PSI* measurement in Table 4.3.2.4-6.		

TABLE 4.3.2.4-6

MEASUREMENT OF STAR ASPECT (ELEVATION) ANGLE (ψ^* ψ_2^* AND ψ· ψ^*) OR (ψ_2^* ψ^* AND ψ_2^* ψ_2^*)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
1	• Given the initial spacecraft configuration shown in the first column of Table 4.3.1.4.3-1, use the existing SRR, which is assumed to be a known star (call it the "SRR" star). • This sequence is to be used only for either one of the following two cases: (1) PSI* is the SRR channel, and PSI2* will be used for Star Gate B. (2) PSI2* is the SRR channel, and PSI* will be used for Star Gate B.		
2	• If not already so, configure the star channel that is not being used as the SRR star channel, for the star to be measured (call it the "measurement" star):		• For the star channel that is the present SRR channel, it is undesirable to change the threshold selection and the bandpass selection. This is to prevent loss of the present SRR star and subsequent loss of DCE control.
STRQ1 OR STRQA	Star Sensor Threshold and Bandpass Select. (Threshold and Bandpass selections are retained on the star channel (PSI* or PSI2*) that is being used as the SRR channel; the alternate channels settings are changed to conform to the measurement star's requirements.)	A*1THS	PSI* Threshold Setting — All Conform to Commanded State
		A*2THS	PSI2* Threshold Setting — All Conform to Commanded State
		A*1BPS	PSI* Bandpass State — All Conform to Commanded State
		A*2BPS	PSI2* Bandpass State — All Conform to Commanded State
3	• Select Star Gate B for the measurement star's channel, but retain Star Gate A selection for the SRR Star;		
ATQ23 (for ADP1 Only)	ADP 1 Configure - ADP Mode Select (Star Gate A - Retain present channel selection. Star Gate B - Channel 1 (if PSI* was selected in Step 2) or Channel 2 (if PSI2* was selected in Step 2).	A*GASS	Star Gate A - No change in TM Reading.
		A*GBSS	Star Gate B = 1 (PSI*) or = 0 (PSI2*), as commanded.

TABLE 4.3.2.4-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
4	• Locate Star Gate B over the measurement star:		
ATQØ5 (for ADP1 Only) (ACSANG = XXX.XX)	ADP 1 Configure - ACS Angle Delay Magnitude. (Calculate $\theta = SEP_{STARS} - BIAS_{STARS} - 0.352^{\circ} - 5.625^{\circ}$ (to locate measurement star in the center of Star Gate B), where SEP_{STARS} = Estimated Azimuthal separation angle measured in plane normal to spin axis from the SRR Star l.o.s. to the measurement star l.o.s. (measured in the direction of S/C spin); and $BIAS_{STARS}$ = value obtained from Table in "Remarks" column). • If θ is positive, then the commanded magnitude = θ. • If θ is negative, then the commanded magnitude = $360^{\circ} + \theta$.	AACSAD	ACS Angle Delay Magnitude = (same magnitude as that commanded).
			SEP_{STARS} = Zero if the SRR Star and the measurement star are the same.
			• Actual delay is 0.352° larger than the commanded value.
			SRR — Corresponding value for $BIAS_{STARS}$
			PSI* — $BIAS_{STARS} = \delta$, where δ is the PSI* to PSI2* spin angle delay in degrees, from Figure 4.3.2.2-4A or -4B, that corresponds to the predicted relative elevation angle of the measurement star w.r.t. the SRR star. NOTE: Use of these figures for bias estimation is not exact when stars of different elevations are involved, as the delay is dependent on SRR star elevation in such a circumstance. However, they are sufficiently accurate for use in positioning Gate B.
			PSI2* — $BIAS_{STARS} = -\delta$, where δ is defined above.

TABLE 4.3.2.4-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
5	Configure ATTM for Star Data:		
ATQØ1 (for ADP1 Only)	ADP 1 Configure - Measurement Select. (SRR to SRR) and (SRR to Gated Star B).	AM1ADS	Measurement A Address: (SRR to SRR)
		AM2ADS	Measurement B Address: (SRR to Star Gate B)
		ATTM1Z OR ATTM2Z	Measurement Data - Reflects above data according to:
		ATTMSS	Data Measurement = 1(A) or = 0(B), alternating no more often than once per spin period as explained in Sections 3.3.2.3.6 & 3.3.3.5.
6	• Accumulate at least 30 valid samples of each measurement. Accept as a valid sample:	ALOCKS	PLL Loss of Lock = 1 (No loss of lock)
	(1) Only the first ATTM1Z or ATTM2Z sample following a change in ATTMSS.	AMISSC	Missed SRR Count = No change from last sample of this parameter.
	(2) Only samples accompanied by the indicated telemetry at the right:	ALOLES	PLL Loss of Lock = 1 (Enabled) } Not Necessary But Preferred
		ASRRMS	Sun/Star Select = 0 (Star)
7	Determine the mean of each set of 30 samples - reject samples outside of 3σ deviation from the mean; then recalculate the mean of the samples.		
8	• Calculate biased "Spin Angle" from SRR Star to the measurement star: AZELDIFF = [(Mean of (SRR to measurement star) samples) (Mean of (SRR to SRR) samples)].		

TABLE 4.3.2.4-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
9	• The actual aspect (elevation) angle of the measurement star, measured w.r.t. the S/C spin axis, may be determined as follows: (a) Retain the star slit in use as the SRR slit, but measure spin angle delay to the measurement star when that same star slit is also assigned to Gate B (i.e., $\psi^* \psi^*$ or $\psi_2^* \psi_2^*$), by performing Steps 1 through 8 of the sequence in Table 4.3.2.4-5 (if not already performed). (b) Calculate $EL_{STAR} = (\Delta)$ [(AZELSAME) - (AZELDIFF)]. • If the SRR slit was the PSI* slit, then $\Delta = +1$. • If the SRR slit was the PSI2* slit, then $\Delta = -1$. (c) Use Figure 3.3.2.2-4A or Figure 3.3.2.2-4B, where $EL_{STAR} \equiv$ PSI* to PSI2* spin angle delay in degrees, to obtain the elevation angle of the measurement star w.r.t. the spacecraft spin axis.		
10	The actual roll (azimuth) angle of the measurement star, measured w.r.t. the SRR star in the spacecraft spin plane and in the direction of positive spacecraft spin, may be determined as follows: (a) Use the known elevation angle of the SRR star to find, from (Figure 3.3.2.2-3A or -3B, if the PSI* slit was used as the SRR slit) or (Figure 3.3.2.2-3C or -3D, if the PSI2* slit was used as the SRR slit), the corresponding position pulse delay angle. Declare this value = AZSRR. (b) Calculate: Roll (Azimuth) Angle of the Measurement Star = AZ_{STAR} = AZELDIFF + AZSRR + AZBIAS + EL_{STAR}, where AZBIAS = value obtained from Remarks column.		SRR: Corresponding value for AZBIAS (from Table 3.3.2.2.6-2:) PSI*: -(B) PSI2*: (B)

TABLE 4.3.2.4-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
10 (Continued)	(c) Optionally, the calculation may be made as follows: AZ_{STAR} = AZELSAME + AZSRR + ELMEAS, where ELMEAS = the position pulse delay angle in degrees from the appropriate one of Figures 3.3.2.2-3A through -3D that corresponds to the measurement star elevation angle found in Step 9 (c), above.		

TABLE 4.3.3-1

ESTABLISHMENT OR TRANSFER OF SELECTED ROLL REFERENCE (SRR)

NOTE: Table 4.3.3-8 exists in the Orbiter Volume (PC-402), but not in the Multiprobe Volume. By keeping this table number blank, subsequent table numbers conform in function between the two volumes.

To SRR → / From SRR ↓	PSI	PSI*	PSI2*	Simulated SRR
Nothing (No SRR established, or Loss of SRR)	Sun Acquisition: Perform the sequence in Table 4.3.3-3.	Star Acquisition (PSI*): Perform the sequence in Table 4.3.3-4, selecting PSI* where pertinent.	Star Acquisition (PSI2*): Perform the sequence in Table 4.3.3-4, selecting PSI2* where pertinent.	Refer to Table 4.3.3-5.
PSI	Transfer to a Different Sensor Input: Perform the sequence in Table 4.3.3-6.	Direct Transfer From Sun to Star: Perform the sequence in Table 4.3.3-7, selecting PSI* where pertinent.	General: Perform the sequence in Table 4.3.3-7, selecting PSI2* where pertinent.	Perform the sequence in Table 4.3.3-9.
PSI*	Perform the sequence in Table 4.3.3-10.	Transfer to a Different Star: Perform the sequence in Table 4.3.3-11, selecting PSI* where pertinent.	Perform the sequence in Table 4.3.3-11, selecting PSI2* where pertinent.	Perform the sequence in Table 4.3.3-9.
PSI2*	Perform the sequence in Table 4.3.3-10.	Perform the sequence in Table 4.3.3-11, selecting PSI* where pertinent.	Transfer to a Different Star: Perform the sequence in Table 4.3.3-11, selecting PSI2* where pertinent.	Perform the sequence in Table 4.3.3-9.
Simulated SRR	Perform the sequence in Table 4.3.3-12.	Perform the sequence in Table 4.3.3-13, selecting PSI* where pertinent.	Perform the sequence in Table 4.3.3-13, selecting PSI2* where pertinent.	

TABLE 4.3.3-2

ASSUMED PERTINENT SPACECRAFT INITIAL CONFIGURATION
JUST PRIOR TO TRANSFER OF SELECTED ROLL REFERENCE (SRR)

Equipment		
$\boxed{\text{Earth Station(s)}}$ in Use:		26 M.
$\boxed{\text{Communications S/S}}$:		Same states as listed in first column of Table 2.3.1-1.
$\boxed{\text{Controls S/S}}$: Star Sensor Channels.		ψ^* and ψ_2^* both ON.
Sun Sensors		Mid-range selected.
Attitude Data Processor	ON/OFF State	ADP 1 ON.
	Measurement Select	A and B Channels in any configuration.
	Jet Control	(1) All Jets Disabled. (2) Spin Rate Detector Enabled. (3) All other choices: DNA
	ADP Mode Select	(1) SRR Advance Inhibited. (2) Sun gate Enabled. (3) Normal selected; SRR or simulated SRR selected, as applicable. Sun or Star selected, as applicable. (4) Star Gates A and B: Channel 1 (ψ^*) or Channel 2 (ψ_2^*) - as applicable, is selected. (5) PLL Loss of Lock enabled. (6) PLL Spin Range of 8.0-17.7 rpm selected.

NOTE: ψ_2 is not available as an SRR.

TABLE 4.3.3-2 (Continued)

Equipment		
Controls S/S : (Cont'd)		
Attitude Data Processor (Cont'd)	ADP Configure Commands 3 Through 11.	1 Jet Countdown: All zeros. 2 ACS Angle: Delay Magnitude DNA. 3 Roll Index Delay Magnitude as required. 4 PLL Spin Period Magnitude - same as prevailing spin period. 5 JCE Buffer Output Disabled.
	Spin Rate	15 RPM.

TABLE 4.3.3-3
SUN ACQUISITION

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
	• Initial conditions are essentially: Both ADPs OFF, both star sensor channels ON, spin rate at 15 rpm, and sun L.O.S. within the field-of-view of the mid-range sun sensor.		
1	• Turn ON ADP #1:		
ADP19 or ADPA9	ADP1 ON	AADP1S	ADP1 ON/OFF = 1 (ON)
		PBUSLI	S/C Loads current increases 250 ma.
		PLIMTI	Bus Voltage Limiter Current likely decreases same amount that PBUSLI has increased.
			• The ADP will initialize in a random manner except for thruster control functions. (Reference Para. 3.3.2.3.2). These will indicate as:
		AJMAGC	JCE Countdown (12 bits) = all zeros.
		AJCEFS	JCE Fire Enable Status = 0. (Disabled).
		AJCE1S	JCE 1 Buffer Output Status = 0 (Disabled).
			Jet Interlock Command Latch (NOT Telemetered) is in the reset (disabled) state.
2	• Configure the ADP:		
2A ATQ02 (for ADP1 Only) (R1 thru A6 = D; SRD = E)	ADP Configure - Jet Control (All jets disabled, Spin rate detector enabled. Remainder are "don't cares", but are set to: Pulse Fire, Pulse Count, 128 ms. normal fire all selected).	AJETSS	Jet Select Bits = All zero (All seven).
		AJETMS (word 2, Bit 6)	Continuous/pulse Fire select = 0 (Pulse)

TABLE 4.3.3-3. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
2A (Cont'd)		AMAGCS	Pulse/Time Count Select = 1 (Pulse)
		APULLS	Pulse Width Select 512/128 ms = 0 (128 ms).
		ASDETS	Spin Rate Detector Enable/Inhibit = 1 (Enabled).
		AJETMS (Word 3, Bit 0)	Normal/Alternate Fire Mode = 1 (Normal).
2B ATQ03 (for ADP1 Only) (SR8,PLD; SGA1; SGB1; SSRM; REFSUN; STN;SUGD; SRANRM).	ADP Configure - ADP Mode Select (*PLL Spin Range of 8.0 to 17.7 rpm selected; PLL Loss of Lock inhibited; Star Gate A and Star Gate B are "don't cares," but Channel 1 is arbitrarily selected; Mid-range sun sensor selected; Sun selected; SRR selected; (Star) Normal selected; Sun Gate disabled; SRR advance inhibited.*)	A*GASS	Star Gate A = 1 (PSI*)
		A*GBSS	Star Gate B = 1 (PSI*)
		ASUNSS	Sun Sensor Select = 00 (Midrange Selected).
		ASRRMS	Sun/Star Select = 1 (Sun)
			SRR/Simulated SRR Select = 1 (SRR)
		A*ACQS	Star Acquisition/Normal = 0 (normal)
		ASPINS	PLL Spin Range = 10 (8.0 - 17.7 rpm)
		ALOLES	PLL Loss of Lock = 0 (Inhibited)
		ASUNGS	Sun Gate = 0 (Disabled)
		ADVANS	SRR Advance = 0 (Not Advanced)
		ALOCKS	PLL Loss of Lock = 1 (In-Lock) - This is not a true indicator of lock status when PLL Loss of Lock has been inhibited.

TABLE 4.3.3-3. (Continued)

COMMAND MNEMONIC OR STEP *	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
2C ATQ05 (For ADP1 Only) ACSANG	ADP Configure - Roll Index Delay Magnitude (Zero Delay).	ARIPAD	Roll Index Delay Magnitude (10 bits) = All Zeros.
2D ATQ01 (For ADP1 Only) (MEA1 = RIP, MEA2 = RIP)	ADP Configure - Measurement Select (SRR to RIP for both measurements A & B).	AM1ADS	Measurement A Address = 010 (SRR to RIP).
		AM2ADS	Measurement B Address = 010 (SRR to RIP).
		ATTM1Z or ATTM2Z (depending on TM format selected).	Attitude Measurement: During Sun Acquisition, this measurement of SRR to RIP (actually Sun to F_s) will behave like a damped sine wave (see Figure 3.3.3.1-2). Once the PLL is in Lock, this measurement provides the steady state phase bias between the SRR and F_s. Average at least 10 samples of SRR to RIP readings and record for later use whenever at the prevailing spin rate (This bias is spin rate dependent.)
3	• After the SRR to RIP readings have stabilized, indicating sun acquisition has occurred (F_s pulse is centered azimuthally in Gate A), proceed to establish the normal operating mode:		
3A ATQ01 (For ADP1 Only) (MEA1 = SRR, MEA2 = S2S)	ADP Configure - Measurement Select (SRR to SRR, and SRR to PSI2).	AM1ADS	Measurement A Address = 000 (SRR to SRR)
		AM2ADS	Measurement B Address = 101 (SRR to PSI2).
		ATTM1Z or ATTM2Z	Actual spin rate and quick look S/C attitude w. r. t. the sun L. o. s. can be determined with these measurements.

TABLE 4.3.3-3. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
3B	• Set simulated SRR period to match actual spin period:		• Simulated SRR period should always be kept within ±1 bit (±0.25 msec) of the actual spin period in order for the SRR to stay within Gate A for 16 minutes at S/C spin rate of 15 rpm (see Para. 3.3.2.3.4 and 3.3.3.2).
ATQØ7 & ATQØ8, OR ATQ78 (For ADP1 Only) SIMSPNPD	ADP Configure - PLL Spin Period Magnitude (Set to actual spin period magnitude as seen via ATTM1Z).	ASIMSZ	PLL Spin Period Magnitude (16 bits) = Same as telemetered via ATTM1Z for SRR to SRR measurement.
ATQØ3 (For ADP1 Only) (PL = E, SUG = E).	ADP Configure - ADP Mode Select (PLL Loss of Lock Enabled, Sun Gate Enabled).	ALOLES	PLL Loss of Lock = 1 (Enabled)
		ASUNGS	Sun Gate = 1 (Enabled)
4	• The science reference signal (RIP) would normally be used after a precise attitude determination has been made.		

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TABLE 4.3.3-4
STAR ACQUISITION
(SUN REFERENCE NOT ATTAINABLE)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
	• This sequence is the same as for Table 4.3.3-3, Sun Acquisition, with the following changes:		
	• The preferred sequence for establishing a star as the SRR is to first select the sun as the SRR and, after a star mapping sequence, transfer to a desired star as the SRR. This sequence assumes that due to S/C attitude or solar eclipse or equipment malfunction, that the sun cannot be used as the intermediate SRR. Regardless of its probability of occurrence, this sequence is included in the matrix of Roll Reference sequences for completeness.		
1 & 2A	• Perform Steps 1 and 2A of Table 4.3.3-3; then configure to acquire the brightest available star (a star map cannot be made in advance because it requires an established SRR. An SRR has not yet been established at this point in the sequence by definition):		
2B1	• Configure PS1* (or PS12*) channel for acquisition of the brightest available star:		
STRQ1 OR STRQA (S2G=4 OR 5, S1G=4 OR 5, S2BW=H, S1BW=H).	Star Sensor Threshold and Bandpass Select (PS1* or PS12*) selected, Threshold setting 4 or 5 generally selected (see "Remarks" column), and 19 Hz Bandpass selected).		• The threshold setting should be selected to minimize false alarm rate and maximize the probability of detection. Knowing the approximate S/C attitude & ephemeris, the brightest available star can be determined. The silicon magnitude of this star can be determined from Table 3.3.3.3-3. The corresponding desired threshold setting can be determined from Figure 3.3.3.3-1 (Desired threshold setting vs. silicon magnitude). (Continued)

TABLE 4.3.3-4 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
2B1 (Continued)			• If PSI* has been selected:
		A*1THS	PSI* Threshold Setting (Analog) - State 4 or 5
		A*1BPS	PSI* Bandpass State = 1 (19 Hz).
			• If PSI2* has been selected:
		A*2THS	PSI2* Threshold Setting (Analog) = State 4 or 5.
		A*2BPS	PSI2* Bandpass State = 1 (19 Hz)
2B2 ATQ03 (For ADP1 Only) (SR8;PLD; (SGA1 & SGB1) OR (SGA2 & SGB2); SSRM; REFSTR; STA;SUGD; SRAADV).	ADP Configure - ADP Mode Select. (PLL Spin range of 8.0 to 17.7 rpm selected; PLL Loss of Lock inhibited; Star Gate A and Star Gate B - both Channel 1 (for PSI* channel usage) OR both Channel 2 (for PSI2* channel usage); Sun sensor select is a "don't care," but midrange is arbitrarily selected; Star selected; Star Acquisition selected; Sun Gate disabled; SRR Advance).	A*GASS	Star Gate A = 1 (PSI*) OR = 0 (PSI2*), as selected.
		A*GBSS	Star Gate B = 1 OR 0 - Same choice as made for A*GASS.
		ASUNSS	Sun Sensor Select = 00 (Mid-range selected).
		ASRRMS	Sun/Star Select = 0 (Star)
			SRR/Simulated SRR = 1 (SRR)
		A*ACQS	Star Acquisition/Normal = 1 (Star Acquisition) • This causes Gate A to be 45° wide.
		ASPINS	PLL Spin Range = 10 (8.0 - 17.7 rpm).
		ALOLES	PLL Loss of Lock = 0 (Inhibited)
		ASUNGS	Sun Gate = 0 (Disabled).
		ADVANS (Cont'd)	SRR Advance = 1 (Advanced) This will change automatically to normal mode (=0) once the new SRR pulse is detected and the PLL resets the phase.

Table 4.3.3-4 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
2B2 (Continued)		ALOCKS	PLL Loss of Lock 1 (In-lock) - This is not a true indicator of Lock status when PLL loss of lock has been inhibited.
2C & 2I	• Perform Steps 2C and 2I of Table 4.3.3-3. Substitute the word "Star" for the word "Sun" in the remarks column.		
3	• After the telemetry listed at the right have stabilized, indicating Star acquisition has occurred (F_s pulse is centered azimuthally in Gate A), proceed to measurement selection:	ATTM1Z OR ATTM2Z (Depending on TM format selected).	SRR to RIP (Telemetered as both Measurement A and Measurement B) has stabilized.
		A*1BRM	PSI* Brightness } The selected star channel output has stabilized in brightness
		A*2BRM	PSI2* Brightness } The selected star channel output has stabilized in brightness
3A ATOØ1 (for ADP 1 only) (MEA1 = SRR, MEA2 = SRR)	ADP Configure - Measurement Select (SRR to SRR, and SRR to SRR).	AM1ADS	Measurement A Address = 000 (SRR to SRR).
		AM2ADS	Measurement B Address = 000 (SRR to SRR).
		ATTM1Z OR ATTM2Z	Actual spin rate can be determined with Measurement A&B.
3B	• Perform Step 3B of Table 4.3.3-3.		

Table 4.3.3-4. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
3C	• Configure for normal operating mode after Star Acquisition		
A1Q03 (PLE; STN; SHGD, SRANRM)	ADP Configure - ADP Mode Select (PLL Loss of Lock Enabled; (Star) Normal selected; Sun Gate state "don't care," but arbitrarily left in disabled state; SRR Advance Inhibited).	ASACQS	Star Acquisition/Normal = 0 (Normal) • This causes Gate A to retract to a width of 11.25°.
		ALOLES	PLL Loss of Lock = 1 (Enabled)
		ADVANS	SRR Advance = 0 (Not Advanced)
4	• A precise attitude determination should follow. Since the sun is not available, and presumably, the star in use as the SRR is not known, a star mapping should be done using Gate B (See Figure 3.3.3.3-1 for the mapping sequence) and all available stars positions used for the attitude determination. If a star other than the one presently functioning as the SRR is the preferred SRR, then a star-to-star transfer should be made after the star mapping (See Table 4.3.3-11) and before the science Reference signal (RIP) is established.		

TABLE 4.3.3-5

SIMULATED SRR "ACQUISITION"

Given no established SRR and the initial conditions listed in Table 4.3.3-2, inability to perform either a sun acquisition or a star acquisition implies multiple S/C failures or an abnormal S/C attitude with the sun l. o. s. along the spin axis and no stars within the star sensor field-of-view. Also, if one were driven to attempt this sequence, one would have to make the best estimate of the present actual spin period based on previous knowledge in order to make the simulated spin period acceptably realistic. Attitude is indeterminate except via the earth l. o. s.

The actual spin period could be approximated in real time by measuring the period in the ground received signal strength signature emanating from a S/C omni antenna.

TABLE 4.3.3-6
SUN TO SUN (DIFFERENT SENSOR INPUT) TRANSFER OF SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
	• Initial conditions are as shown in Table 4.3.3-2 (essentially: ADP1 ON; Fwd Omni in use for Uplink and Downlink; PSI is the SRR; and sun sensor mid-range selected.		
	• Without speculating about the probability of occurrence of this sequence, it is presented here for completeness:		
1	• Choose any detectable star for the purpose of bias measurement. • Measure and record the (SRR to Gated Star B) ATTM to this "bias measurement" star - converted to spin angle delay via (SRR to SRR) ATTM. Also, record the intensity of this "bias measurement" star for aid in its identification:		
2	• Configure either PSI* or PSI2* channel for measurement of the "bias measurement" star:		
STRQ1 or STRQA	Star sensor Threshold and Bandpass Select (PSI* or PSI2* Selected, Threshold setting and bandpass selected for acceptable probability of detection of "bias measurement" star).	A*1THS	PSI* Threshold Setting } At commanded settings, according to star channel selected
		A*1BPS	PSI* Bandpass state
		A*2THS	PSI2* Threshold Setting
		A*2BPS	PSI2* Bandpass State

TABLE 4.3.3-6. (Continued)

COMMAND MNEMONIC OR STEP *	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA	
3	• Locate Gate B over the "bias measurement" star:			
ATC05 (For ADP 1 Only) (ACSANG)	ADP Configure - ACS Angle Delay Magnitude Calculate θ = $SEP_{SUNSTAR}$ - $BIAS_{SUNSTAR}$ - 0.352° - 5.625°, where: • $SEP_{SUNSTAR}$ = Azimuthal separation angle measured in the plane normal to the S/C spin axis from the sun l.o.s. to the "bias measurement" star (measured in the direction of S/C spin); and: • $BIAS_{SUNSTAR}$ = value obtained from table in "REMARKS" column.) • If θ is positive, commanded magnitude θ. • If θ is negative, commanded magnitude = 360° θ.	AACSAD	ACS Angle Delay Magnitude = Value Commanded.	
			• This action here, plus Star Gate B selection in the next step, will position the "bias measurement" star to be in the center of Gate B.	
			• Actual delay is 0.352° larger than the commanded value.	
			Gate B Star Channel:	Corresponding value (from Tables 3.3.2.2.6-1 and 3.3.2.2.6-2 for $BIAS_{SUNSTAR}$:
			PSI*	-(1)-(2)-(3)+(A)+(B)+(C).
			PSI2*	-(1)-(2)-(3)+(A)+(B).

TABLE 4.3.3-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
4	• Select Star Gate B for the star channel chosen in Step 2:		
ATQØ3 (for ADP 1 Only)	ADP Configure - ADP Mode Select (Star Gate B = 1 or 2 (For PSI* Channel or PSI2* channel, respectively, as selected in Step 2)).	A*GBSS	Star Gate B = 1 (PSI*) <u>or</u> = 0 (PSI2*), as commanded.
		A*1BRM	PSI* Brightness } According to star channel selected, should have stabilized to a value recognizable as that of the "bias measurement" star.
		A*2BRM	PSI2* Brightness
5	• Configure for and record present spin angle delay to "bias measurement" star:		
ATQØ1 (for ADP 1 Only) (MEA1 = SRR, MEA2 = GSB)	ADP Configure - Measurement Select (SRR to SRR) and (SRR to Gated Star B):	ATTM1Z <u>or</u> ATTM2Z	Attitude Measurements • Calculate spin angle delay to "bias measurement" star. Call it "PRE-MEAS"
6	• Transfer the SRR to the extended range sun sensor of choice:		
ATQØ3 (for ADP1 Only).	ADP Configure - ADP Mode Select (Sun sensor extended range upper <u>or</u> lower selected; all other selections not changed).	ASUNSS	Sun Sensor Select = 01 (Extended Range Lower) or = 10 (Extended Range Upper), as commanded.
		ATTM1Z <u>or</u> ATTM2Z	Attitude Measurements • Calculate spin angle delay to "bias measurement" star. Call it "POST-MEAS."
			All other TM as before.

TABLE 4.3.3-6 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
7	● Configure for and record present ATTM measurement for RIP delay (if not already known):		
ATQØ1 (for ADP 1 Only) (MEA1 = SRR MEA2 = RIP)	ADP Configure - Measurement Select (SRR to SRR) and (SRR to RIP).	ATTM1Z *or* ATTM2Z	Attit[illegible] measurements: ● Record present readings. Convert to spin angle delay via use of spin period.
		ARIPAD	Roll Index Delay Magnitude: ● Record present value (This is the last commanded value) for later use.
8	Readjust RIP delay w. r. t. new SRR:		
ATQØ6 (for ADP 1 Only) RIPANG	ADP Configure - Roll Index Delay Magnitude (Magnitude = (ARIPAD value from Step 7) + "CHANGE," where: "CHANGE" = ("PREMEAS" (from Step 5)) - ("POST-MEAS" (from Step 6)).	ARIPAD	Roll Index Delay Magnitude = Commanded Value.
		ATTM1Z *or* ATTM2Z	(SRR to RIP): Step Function change by a magnitude = "CHANGE."
			● RIP should now be occurring spatially as prior to the SRR transfer.

TABLE 4.3.3-7.
SUN TO STAR TRANSFER OF SRR

Command Mnemonic Or Step #	Command or Action	Remarks & Verification	
		Telemetry Mnemonic	Remarks & TM Data
	• Initial conditions are as shown in Table 4.3.3-2. (Essentially: ADP1 ON; Forward Omni in use for uplink and downlink; and PSI is the SRR).		
1 (BIAS)	• The S/C attitude should be well known on a continuous basis. However, an updating of the star map may be required periodically; and, if needed, should be performed prior to transfer to a star SRR - preferably during apoapsis.		
	• Perform a complete or limited star map per the sequence in Figure 3.3.3.3-2, as required. As a minimum, map the immediate azimuthal vicinity (10°, in 2° segments) of the star that is the SRR candidate. • As a minimum, record (SRR to SRR) and concurrently, the (SRR to Gated Star B) ATTM values, (1) using PSI* channel for Star Gate B with the SRR candidate star. and (2) using PSI2* channel for Star Gate B with the SRR candidate star. • Translate above to spin angle delays, using (SRR to SRR) measurement(s).		
2 (BIAS) (RT)	• Configure PSI* (or PSI2*) channel for use as the SRR channel for the SRR candidate star:		
STRQ1 OR STRQA	Star Sensor Threshold and Bandpass Select (PSI* (or PSI2*) selected, Threshold Setting and Bandpass Selected for acceptable probability of Detection of SRR Candidate Star).	A*1THS	PSI* Threshold Setting — At commanded settings, according to Star Channel Selected.
		A*1BPS	PSI* Bandpass State
		A*2THS	PSI2* Threshold Setting
		A*2BPS	PSI2* Bandpass State

TABLE 4.3.3-7 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & TM DATA	
3	• Locate Gate B over the SRR candidate star:			
ATQ05 (For ADP 1 Only) (ACSANG)	ADP Configure - ACS Angle Delay Magnitude Calculate $\theta = SEP_{SUNSTAR} - BIAS_{SUNSTAR} - 0.352^{\circ} - 5.625^{\circ}$, where: • $SEP_{SUNSTAR}$ = Azimuthal separation angle measured in the plane normal to the S/C spin axis from the sun l.o.s. to the "bias measurement" star (measured in the direction of S/C spin); and: • $BIAS_{SUNSTAR}$ = value obtained from table in "REMARKS" column.) • If θ is positive, commanded magnitude = θ. • If θ is negative, commanded magnitude = $360^{\circ}+\theta$.	AACSAD	ACS Angle Delay Magnitude = Value Commanded.	
			• This action here, plus Star Gate B selection in the next step, will position the "bias measurement" star to be in the center of Gate B.	
			• Actual delay is 0.352° larger than the commanded value.	
		Gate	Gate B Star Channel:	Corresponding value (from Tables 3.3.2.2.6-1 and 3.3.2.2.6-2) for $BIAS_{SUNSTAR}$:
			PSI*	-(1)-(2)-(3)+(A)+(B)+(C).
			PSI2*	-(1)-(2)-(3)+(A)+(C)

TABLE 4.3.3-7. (Continued)

Command Mnemonic Or Step #	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
4	• Select Star Gates A and B for the desired SRR star channel (selected in Step 2):		
ATQ03 (For ADP1 Only)	ADP Configure - ADP Mode Select (Star Gates A and B both channel 1 (for PSI* channel usage) or both channel 2 (for PSI2* channel usage)).	A*GASS	Star Gate A = 1 (PSI*) OR = 0 (PSI2*), as commanded
		A*GBSS	Star Gate B = 1 or = 0 - Same choice as made for A*GASS.
			All other ADP Mode states should be unchanged.
5	Configure for and record all present remaining pertinent ATTM and associated measurements for post-transfer use; then configure finally for measurement during transfer:		
	(Continued)		

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TABLE 4.3.3-7. (Continued)

Command Mnemonic Or Step #	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data
5 (Continued) (MEA1 = SRR, MEA2 = RIP; then MEA1 = SRR, MEA2 = GSB)	ADP Configure - Measurement Select ((SRR to SRR) and (SRR to RIP), terminating with (SRR to Gated Star B) and (SRR to SRR))	ATTM1Z OR ATTM2Z	Attitude Measurement: • Record, when S/C is configured, the following for post-transfer use: (SRR to SRR), and (SRR to RIP) • SRR to Gated Star B) should stabilize to less than 0.3° variations.
		A*1BRM	PSI* Brightness } According to Star Channel selected - should have stabilized to value recognizable as that of the SRR candidate star.
		A*2BRM	PSI2* Brightness
		ARIPAD	RIP Magnitude } Record values for post-transfer Use.
		AACSAD	ACS Angle Delay Magnitude
		ASIMSZ	PLL Spin Period Magnitude

Table 4.3.3-7. (Continued)

Command Mnemonic Or Step #	Command or Action	Remarks & Verification: Telemetry Mnemonic	Remarks & Verification: Remarks & TM Data	
6	• Calculate required azimuth angle for RIP delay: • = (Last azimuth command value used in step 5 + "Δ" + TMSEP, where "Δ" & TMSEP are obtained from Table in the "Remarks" column. • If G < 360°, then "AZRIP" = G • If G ≥ 360° then "AZRIP" = G - 360°		• "Δ" may be obtained from prelaunch tests or updated during the mission using offline statistical processing of appropriate downlink information.	
			Star Channel chosen in step 2:	Corresponding value for TMSEP:
			PSI*	Value obtained in (1) of step 1.
			PSI2*	Value obtained in (2) of step 1.

TABLE 4.3.3-7. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
7	• Transfer the SRR to the candidate star:		
ATQ03 (For ADP1 Only) (PLD; REFSTR; SRAADV)	ADP Configure - ADP Mode Select (PLL Loss of Lock Inhibited; Star Selected; SRR Advance Selected).	ASRRMS	Sun/Star Select = 0 (Star)
		ALOLES	PLL Loss of Lock = 0 (Inhibited)
		ADVANS	SRR Advance = 1 (Advanced) This will change automatically to normal mode (= 0) once the new SRR pulse is detected and the PLL resets the phase.
			Phase reference of PLL will transfer to Star located in Gate B. • Star will leave Gate B, but stay in Gate A.
		ALOCKS	PLL Loss of Lock = 1 (In-Lock) - This is <u>not</u> a true indicator of Lock status when PLL Loss of Lock has been inhibited.
		A*1BRM	PSI* Brightness — According to channel selected, brightness will drop to zero, indicating star has left Gate B.
		A*2BRM	PSI2* Brightness — According to channel selected, brightness will drop to zero, indicating star has left Gate B.
		ATTM1Z OR ATTM2Z	Attitude Measurements: • If SRR to Gated Star B is one of the selected measurement channels (e.g., during bias measurement effort near apoapsis), as soon as the star leaves Gate B, this measurement can no longer be made, and ATTM measurements A and B will no longer cycle. The last valid measurement from the alternate selected value (in this case, SRR to SRR will be continuously telemetered for both A and B measurement slots. Refer to Para. 3.3.3.9.2

TABLE 4.3.3-7 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
8 (BIAS)	• Configure for and record present ATTM measurements for RIP Delay.		
ATQØ1 (for ADP1 Only)	ADP Configure - Measurement select (SRR to SRR) and SRR to RIP).	ATTM1Z or ATTM2Z	Attitude Measurements: o Record present readings. Convert to spin angle delays via use of last known spin period.
9	Readjust RIP Delay w.r.t. new SRR:		
ATQØ6 (for ADP1 Only)	ADP Configure - Roll Index Delay Magnitude (Magnitude = Value of "AZRIP" calculated in Step 6).	ARIPAD	Roll Index Delay Magnitude = Commanded Value.
		ATTM1Z or ATTM2Z	SRR to RIP - Step function change by a magnitude = "Δ" + TMRIP (defined in Step 6)
10	• Establish normal post-transfer mode for ADP:		
ATQØ3 (for ADP1 Only) (PLE; SRANRM).	ADP Configure - ADP Mode Select (PLL Loss of Lock Enabled; SRR Advance reset).	ADVANS	SRR Advance = 0 (Not advanced)
		ALOLES	PLL Loss of Lock = 1 (Enabled)
		ALOCKS	PLL Loss of Lock - Now a true indicator.
			All other TM as before.

TABLE 4.3.3-8

This table exists in the Orbiter Volume (PC-402), but not in the Multiprobe Volume (PC-403). By keeping this table number blank, subsequent table numbers conform in function between the two volumes.

TABLE 4.3.3-9

SUN OR STAR TO SIMULATED SRR TRANSFER OF SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
	• Initial conditions are as shown in Table 4.3.3-2. (Essentially: ADP 1 ON; Forward Omni in use for uplink and downlink; and PSI or PSI* or PSI2* is the SRR).		
	• This sequence will be used normally only if the sun and all reliably detectable stars will not be available imminently as an SRR.		
1	• Configure for and record present ATTM measurements for the spin period, and simulated spin period.		
ATQ01 (For ADP1 Only) (MEA1 = SRR MEA2 = SRR)	ADP Configure - Measurement Select. ((SRR to SRR) and (SRR to SRR)).	ATTM1Z or ATTM2Z	Attitude Measurements: • Record at least 30 successive samples (SRR to SRR).
		ASIMSZ	PLL Spin Period Magnitude (16 bits) } Record this simulated spin period magnitude.
2	• Determine the mean of 30 successive samples of (SRR to SRR) - reject samples outside of 3σ deviation from the mean; then recalculate the mean of the remaining samples.		
3	• Change the simulated spin period magnitude to be the mean value calculated in Step 2.		
ATQ07 (For ADP1 Only).	If the MSBs have to be changed: ADP Configure - PLL Spin Period Magnitude (MSBs).	ASIMSZ	PLL Spin Period Magnitude (8 MSB of 16 bits). } Same as that Commanded.
ATQ08 (For ADP1 Only).	If the 8 LSBs have to be changed: ADP Configure - PLL Spin Period Magnitude (LSBs).	ASIMSZ	PLL Spin Period Magnitude (8 LSB of 16 bits). } Same as that Commanded.
4	Transfer to the simulated SRR:		

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TABLE 4.3.3-9 (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
4 ATQØ3 (For ADP1 Only) (PLD; REFSIM)	ADP Configure - ADP Mode Select (PLL Loss of Lock Inhibited; Simulated SRR Selected).	A1OLES	PLL Loss of Lock = 0 (Inhibited)
		A1LOCKS	PLL Loss of Lock = 1 (In-Lock) - This is not a true indicator of lock status when PLL Loss of Lock has been inhibited.
		ASRRMS (Word 4, Bit 6)	SRR/Simulated SRR = 0 (Simulated SRR)
		ATTM1Z or ATTM2Z	Attitude Measurements - (SRR to SRR) now indicates last commanded simulated SRR spin period.

TABLE 4.3.3-10
STAR TO SUN TRANSFER OF SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
	• Initial conditions are as shown in Table 4.3.3-2 (Essentially: ADPI ON; Forward Omni In use for uplink and downlink; and either PSI* channel or PSI2* channel is in use for the SRR).		
1 Through 5	• Perform Steps 1 through 5 of Table 4.3.3-6 (Sun to Sun (Different Sensor Input) Transfer of SRR), with one exception: In Step 2, configure the star channel (PSI* or PSI2*) that is not being used as the pre-transfer SRR Star Channel.		
6	Transfer the SRR to any one of the three sun sensors of choice:		
ATQ#3 (For ADPI Only) (PLD; SSRX; REFSUN; SUGD; SRAADV)	ADP Configure - ADP Mode Select (PLL loss of lock inhibited; sun sensor midrange or extended range upper or extended range lower; sun selected; Sun Gate Disabled; SRR Advance selected).	ASUNSS	Sun Sensor Select = 00 (Mid-Range) or =01 (Extended Range Lower) or = 10 (Extended Range Upper), as commanded.
		ASRRMS (Word 4, Bit 5)	Sun/Star Select = 1 (Sun)
		ALOLES	PLL Loss of Lock = 0 (Inhibited)
		ALOCKS	PLL Loss of Lock = 1 (In-Lock). This is not a true indicator of Lock status when PLL Loss of Lock has been inhibited.
		ADVANS	SRR Advance = 1 (Advanced) This will change automatically to normal mode (=0) once the new SRR pulse is detected and the PLL resets the phase.
		ATTM1Z OR ATTM2Z	Attitude Measurements - • Calculate spin angle delay to "bias measurement" star. Call it "POST-MEAS"
			• All other TM as before.

TABLE 4.3.3-10. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
7 and 8	• Perform Steps 7 and 8 of Table 4.3.3-6.		
9	• Establish normal post-transfer mode for ADP:		
ATC003 (For ADP1 Only) (PLE; SUGE; SRANRM)	ADP Configure - ADP Mode Select (PLL loss of lock enabled; Sun Gate enabled; SRR Advance inhibited).	ASUNGS	Sun Gate = 1 (Enabled)
		ALOLES	PLL Loss of Lock = 1 (Enabled)
		ALOCKS	PLL Loss of Lock - Now a true indicator.
		ADVANS	SRR Advance = 0 (Not Advanced)
			All Other TM as Before.

TABLE 4.3.3-11
STAR TO STAR TRANSFER OF SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION: TELEMETRY MNEMONIC	REMARKS & VERIFICATION: REMARKS & TM DATA
	• **Initial Conditions are as shown in Table 4.3.3-2. (Essentially: ADP1 ON; Forward Omni use for uplink and downlink; and either PS1* channel or PS12* channel is in use for the SRR).**		
	• **This sequence assumes the sun is not available either as an SRR or for ATTM measurements to the PS12 channel.** • **The S/C Attitude should be well known on a continuous basis. However, an updating of the Star Map may be required periodically; and, if needed, should be performed prior to transfer to a different star as the SRR.**		
1 Through 3	• **Perform Steps 1 through 3 of Table 4.3.3-7, (Sun to Star Transfer of SRR), with one exception:** **For the star channel that is the present SRR channel, it is undesirable to change the threshold selection and the bandpass selection. This is to prevent loss of the present SRR star.**		
4	• **Select Star Gate B for the desired SRR Star channel (selected in Step 2), but retain Star Gate A selection for the present SRR;**		

Table 4.3.3-11. (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
4 (Cont'd) ATQ03 (For ADP1 Only)	ADP 1 Configure - ADP Mode Select (Star Gate A - Retain present channel selection. Star Gate B - Channel 1 (if PSI* was selected in Step 2) or Channel 2 (if PSI2* was selected in Step 2)).	A*GASS	Star Gate A - No change in TM reading.
		A*GBSS	Star Gate B = 1 (PSI*) or = 0 (PSI2*), as commanded.
5 Through 7	• Perform Steps 5 through 7 of Table 4.3.3-7, with the following exception: In Step 7, include Star Gate A channel selection to be the same as the prevailing Star Gate B channel selection. (If it is not already the same).	A*GASS	Star Gate A = 1 or = 0 - Same as for A*GBSS (Star Gate B).
8 Through 10	• Perform Steps 8 through 10 of Table 4.3.3-7.		

TABLE 4.3.3-12. Simulated SRR to Sun Transfer of SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
	• Initial conditions are as shown in Table 4.3.3-2 (Essentially: ADP1 ON; forward omni in use for uplink and downlink; and simulated SRR is the SRR).		
	• Without speculating about the probability of occurrence of this sequence, the sequence is presented here for completeness.		
1 Through 5	• Perform Steps 1 through 5 of Table 4.3.3-6 (Sun to Sun (Different Sensor Input) Transfer of SRR)		
6	Transfer the SRR to anyone of three sun sensors of choice:		
ATQ03 (For ADP1 Only)	ADP Configure - ADP Mode Select (Command #2) (Sun sensor mid-range <u>or</u> extended range upper <u>or</u> extended range lower; SRR Advance, Sun Gate disable, SRR, Sun - all selected; PLL Loss of Lock inhibited).	ASUNSS	Sun Sensor Select = 00 (Mid-Range) <u>or</u> = 01 (Extended Range Lower) <u>or</u> = 10 (Extended Range Upper), as commanded.
		ASRRMS (Word 4 Bit 5)	Sun/Star Select = 1 (Sun)
		ALOLES	PLL Loss of Lock = 0 (Inhibited)
		ALOCKS	PLL Loss of Lock = 1 (In-Lock). This is <u>not</u> a true indicator of lock status when PLL Loss of Lock has been inhibited.
		ADVANS	SRR Advance = 1 (Advanced) This will change automatically to normal mode (=0) once the new SRR pulse is detected and the PLL resets the phase.
		ATTM1Z OR ATTM2Z	Attitude Measurements: • Calculate spin angle delay to "bias measurement" star. Call it "POST-MEAS"
			All other TM as before.

Table 4.3.3-12. Simulated SRR to Sun Transfer of SRR (Continued)

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
7 and 8	• Perform Steps 7 and 8 of Table 4.3.3-6.		
9	• Establish normal post-transfer mode for ADP:		
ATQ~~0~~3 (For ADP1 Only)	ADP Configure - ADP Mode Select (Command #2) (Sun Gate Enabled, PLL Loss of Lock Enabled).	ASUNGS	Sun Gate = 1 (Enabled)
		ALOLES	PLL Loss of Lock = 1 (Enabled)
		ALOCKS	PLL Loss of Lock - Now a true indicator
			• All Other TM as Before.

TABLE 4.3.3-13. Simulated SRR to Star Transfer of SRR

COMMAND MNEMONIC OR STEP #	COMMAND OR ACTION	REMARKS & VERIFICATION	
		TELEMETRY MNEMONIC	REMARKS & TM DATA
	• Initial conditions are as shown in Table 4.3.3-2. (Essentially: ADP1 ON; forward omni in use for uplink and downlink; and simulated SRR is the SRR).		
	• This is a general purpose sequence.		
1 Through 10	• Perform Steps 1 through 10 of Table 4.3.3-7, Sun to Star Transfer of SRR, except do only the limited star mapping in Step 1 <u>at the most</u>. The true spin period of the S/C can easily deviate ±1 bit (0.325 milliseconds) due to various causes, so that this transfer from the simulated SRR should be done expediently, as the SRR Candidate star can drift out of star Gate B in a matter of tens of minutes (Refer to Para. 3.3.3.7.5 for further discussion of drift Rate). It is also necessary to include SRR Select in Step 7.	ASRRMS (Word 4, Bit 6)	SRR/Simulated SRR = 1 (SRR)

TAB. 4.3.5.3-1

POWER PROFILE FOR BUS

Subsystem/Units			Pre-Launch & Launch Units On/Sby/Off	Pre-Launch & Launch Watts/Amps 27.5V	Cruise #1 Units On/Sby/Off	Cruise #1 Watts/Amps 28.0 V.	TCM #1 Units On/Sby/Off	TCM #1 Watts/Amps 28.0 V.	Cruise #2 Units On/Sby/Off	Cruise #2 Watts/Amps 28.0 V.	Reorientation Units On/Sby/Off	Reorientation Watts/Amps 28.0 V.	Probe Checkout Units On/Sby/Off	Probe Checkout Watts/Amps 28.0 V
Start Time				-0.500 Hrs.		L+2.0 Days		L+5.0 Days		L+80.0 Days		E-28.0 Days		E-28.0 Day.
Mode Duration				1.00 Hr.		0.00 Hr.		0.00 Hr.		0.00 Hr.		0.00 Hr.		0.300 Hr.
Sun Angle				0.00 Deg.		90.00 Deg.		90.00 Deg.		90.00 Deg.		19.00 Deg.		49.00 Deg.
Solar Dist.				151.60 Mkm		151.60 Mkm		151.60 Mkm		127.50 Mkm		120.80 Mkm		120.80 Mkm
Comm(RF)	Xpndr-Rcvr	P	2/0/0	4.10/0.160	2/0/0	4.40/0.157	2/0/0	4.10/0.157	2/0/0	4.40/0.157	2/0/0	4.40/0.157	2/0/0	4.40/0.157
	Xpndr-Xctr	P	1/0/1	3.90/0.142	1/0/1	3.90/0.139	1/0/1	3.90/0.139	1/0/1	3.90/0.139	1/0/1	3.90/0.139	1/0/1	3.90/0.139
	Power Amps	I	1/0/3	31.63/1.150	1/0/3	32.20/1.150	1/0/3	32.20/1.150	2/0/2	64.40/2.300	1/0/3	32.20/1.150	2/0/2	64.40/2.300
	Driver Amps	I	1/0/3	10.31/0.375	1/0/3	10.50/0.375	1/0/3	10.50/0.375	2/0/2	21.00/0.750	1/0/3	10.50/0.375	2/0/2	21.00/0.750
	Switches	I	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007
Subtotal				50.44/1.834		5[illegible]/1.828		51.20/1.828		93.90/3.353		51.20/1.818		93.90/3.353
Data	Tel. Proc.	I	1/0/1	7.78/0.283	1/0/1	7.92/0.283	1/0/1	7.12/0.2	1/0/1	7.92/0.283	1/0/1	7.92/0.283	1/0/1	7.92/0.283
	PCM Enc.Dims	I	1/0/1	4.03/0.146	1/0/1	4.10/0.146	1/0/1	4.10/0.146	1/0/1	4.10/0.146	1/0/1	4.10/0.146	1/0/1	4.03/0.146
Subtotal				11.01/0.429		12.02/0.429		12.02/0.429		12.02/0.429		12.02/0.429		12.02/0.429
Command	CMD PP+7Cms	I	2/0/0	9.02/0.328	2/0/0	9.18/0.328	2/0/0	9.18/0.328	2/0/0	9.18/0.328	2/0/0	9.18/0.328	2/0/0	9.18/0.328
	CMD Mem.	I	?/0/0	0.00/0.000	0/0/2	0.00/0.000	1/0/1	1.99/0.071	0/0/2	0.00/0.000	0/0/2	0.00/0.000	0/0/?	0.00/0.000
	Pyro Control	I	/2/0	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004
Subtotal				9.1?/0.332		9.30/0.332		11.29/0.403		9.30/0.332		9.30/0.332		9.30/0.332
Controls	Att Data Proc.	I	0/0/2	0.00/0.000	1/0/1	6.90/0.246	1/0/1	6.90/0.245	1/0/1	6.90/0.246	1/0/1	6.90/0.246	1/0/1	6.90/0.246
	Jet Cont. E	I	0/0/2	0.00/0.000	0/0/2	0.00/0.000	1/0/1	0.12/0.004	0/0/2	0.00/0.000	0/0/2	0.00/0.000	0/0/2	0.00/0.000
	Driver I	I	2/0/0	0.03/0.001	2/0/0	0.03/0.001	2/0/0	1.53/0.055	2/0/0	0.03/0.001	2/0/0	0.03/0.001	[illegible]	0.03/0.001
	Star Sensor	P	0/0/1	0.00/0.000	1/0/0	1.29/0.046	1/0/0	1.29/0.046	1/0/0	1.29/0.046	1/0/0	1.29/0.046	1/0/0	1.29/0.046
Subtotal				0.03/0.001		8.22/0.294		9.81/0.351		8.22/0.294		8.22/0.294		8.22/0.294
Prop.	Jet Valves	R	0/8/0	0.00/0.000	0/6/0	0.00/0.000	1/5/0	17.80/0.638	0/6/0	0.00/0.000	0/6/0	0.00/0.000	0/6/0	0.00/0.000
	R. Jet Htr R14	R	2/0/0	0.57/0.021	2/0/0	0.59/0.021	2/0/0	0.59/0.021	2/0/0	0.59/0.021	2/0/0	0.59/0.021	2/0/0	0.59/0.021
	R. Jet Htr R23	R	2/0/0	3.36/0.122	2/0/0	3.48/0.124	2/0/0	3.48/0.124	2/0/0	3.48/0.124	2/0/0	3.48/0.124	2/0/0	3.48/0.124
	A. Jet Htr A5	R	1/0/0	0.83/0.030	1/0/0	0.86/0.031	1/0/0	0.86/0.031	1/0/0	0.86/0.031	1/0/0	0.86/0.031	1/0/0	0.86/0.031
	A. Jet Htr A6	R	1/0	1.14/0.041	1/0/0	1.18/0.042	1/0/0	1.18/0.042	1/0/0	1.18/0.042	1/0/0	1.18/0.042	1/0/0	1.18/0.042
	Prop. Tnk.Htrs	R	1/0/1	16.71/0.608	1/0/1	17.36/0.620	1/0/1	17.36/0.630	1/0/1	17.36/0.620	1/0/1	17.36/0.620	1/0/1	17.36/0.620
Subtotal				22.61/0.822		23.47/0.838		41.27/1.471		23.47/0.838		23.47/0.838		23.47/0.838
Probes	L. P. Htr	R	0/0/1	0.00/0.000	1/0/0	21.50/0.768	1/0/0	21.50/0.768	1/0/0	21.50/0.768	0/0/1	0.00/0.000	0/0/1	0.00/0.000
	S. P. Htrs	R	0/0/3	0.00/0.000	3/0/0	0.00/0.000	3/0/0	0.00/0.000	0/0/3	0.00/0.000	0/0/3	0.00/0.000	0/0/3	0.00/0.000
	CkO Pwr-CDU	I	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	1/0/0	7.59/0.271
	CkO Pwr Sci.	I	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	1/0/0	56.00/2.000
	Cmd Inhibit	R	0/0	0.11/0.015	1/0/0	0.13/0.015	1/0/0	0.13/0.015	1/0/0	0.13/0.015	1/0/0	0.43/0.015	4/0/0	0.41/0.015
Subtotal				0.11/0.015		21.92/0.783		21.92/0.783		21.93/0.783		0.13/0.015		63.87/2.286
Power	Batt Chg.	R	0/2/0	0.00/0.000	2/0/0	9.80/0.350	2/0/0	9.80/0.350	2/0/0	9.80/0.350	2/0/0	9.80/0.350	0/2/0	9.80/0.350
	Bus Limiter	R	0/?/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025
	Lock-Over Sw	R	1/0/0	0.36/0.013	1/0/0	0.36/0.013	1/0/0	0.36/0.013	1/0/0	0.36/0.013	1/0/0	0.36/0.013	1/0/0	0.36/0.013
	Current Sensor	R	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010
	Power I'ferf.	R	1/0/0	0.19/0.007	1/0/0	0.20/0.007	1/0/0	0.20/0.007	1/0/0	0.20/0.007	1/0/0	0.20/0.007	1/0/0	0.20/0.007
	Batt. Disch.	R	2/0/0	2.20/0.080	0/2/0	1.40/0.050	0/2/0	1.40/0.050	0/2/0	1.40/0.050	0/2/0	1.40/0.050	0/2/0	1.40/0.050
Subtotal				3.73/0.135		12.71/0.455		12.71/0.455		12.71/0.455		12.71/0.455		12.71/0.455
Distribution Loss				2.92		3.92		3.72		1.91		3.18		5.19
S/C Total				100.25/3.564		142.79/4.959		164.00/5.723		186.19/6.181		120.86/4.191		228.84/7.987
Science		P	0/0/1	0.00/0.000	1/0/0	30.00/1.071	0/0/1	0.00/0.000	1/0/0	30.00/1.071	1/0/0	30.00/1.071	1/0/0	0.00/0.000
Total S/C Loads				100.25/3.564		172.79/6.030		164.00/5.723		216.19/7.555		150.86/5.262		228.84/7.987
Solar Panel Power				0.00/0.000		227.56/8.128		227.56/8.128		288.83/10.314		240.58/8.592		240.58/8.592
Solar Panel Contingency				/0.000		/2.098		/2.405		/2.689		/3.330		/0.605
Battery Amps Used				/3.568		/0.000		/0.000		/0.000		/0.000		/0.000
Battery Amperes Required				3.568 Amps.		0.000 Amps.		0.000 Amps.		0.000 Amps.		0.000 Amps		0.000 Amps
Battery Discharge Depth				23.8 Percent		0.0 Percent		0.0 Percent		0.0 Percent		0.0 Percent		0.0 Percent

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TABLE 4.3.5.3-1 (Continued)

Subsystem/Units			Large Probe Release		SP Release - High Power		SP Release - Low Power		Bus Target		Pre-Entry	
Start Time			E-24.0 Days		E-20.0 Days		E-20.0 Days		E-18.0 Days		E-1.5 Days	
Mode Duration			0.00 Hr.		2.00 Hr.		2.00 Hr.		0.00 Hr.		0.00 Hr.	
Sun Angle			24.50 Deg.		17.00 Deg.		17.00 Deg.		26.30 Deg.		56.50 Deg.	
Solar Dist.			118.70 Mkm		116.60 Mkm		116.60 Mkm		115.60 Mkm		107.60 Mkm	
			Units On/Sby/Off	Watts/Amps 27 .V	Units On/Sby/Off	Watts/Amps 27.5 V	Units On/Sby/Off	Watts/Amps 27.5 V	Units On/Sby/Off	Watts/Amps 28.0 V	Units On/Sby/Off	Watts/Amps 28.0 V
Comm (RF)	Xpndr-Rcvr	P	2/0/0	4.40/0.130	2/0/0	4.40/0.160	2/0/0	4.40/0.160	2/0/0	4.40/0.157	2/0/0	4.40/0.157
	Xpndr-Exciter	P	1/0/1	3.90/0.142	1/0/1	3.90/0.147	1/0/1	3.90/0.142	1/0/1	3.90/0.139	1/0/1	3.90/0.139
	Power Amps	I	2/0/2	63.25/2.369	1/0/1	63.25/2.300	1/0/3	31.63/1.150	1/0/3	32.20/1.150	2/0/2	64.40/2.300
	Driver Amps	I	2/0/2	20.63/0.759	2/0/2	20.63/0.750	1/0/3	10.31/0.375	1/0/3	10.50/0.375	2/0/2	21.00/0.750
	Switches	I	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007	0/1/0	0.20/0.007
Subtotal				92.18/3.359		92.18/3.359		50.44/1.834		51.20/1.828		93.90/3.353
Data	TCI Processor	I	1/0/1	7.78/0.283	1/0/1	7.78/0.283	1/0/1	7.78/0.283	1/0/1	7.92/0.283	1/0/1	7.92/0.283
	PCM Enc & Dims	I	1/0/1	4.10/0.146	1/0/1	4.03/0.146	1/0/1	4.03/0.146	1/0/1	4.10/0.146	1/0/1	4.10/0.146
Subtotal				11.81/0.429		11.81/0.429		11.81/0.429		12.02/0.429		12.02/0.429
Command	CMD PR & Coms	I	1/0/0	9.07/0.328	2/0/0	9.02/0.328	2/0/0	9.02/0.328	2/0/0	9.18/0.328	2/0/0	9.18/0.328
	CMD Memory	I	0/0/2	0.00/0.000	0/0/2	0.00/0.000	0/0/2	0.00/0.000	1/0/1	1.99/0.071	1/0/1	1.99/0.071
	Pyro Control	I	0/2/0	0.12/0.004	0/0/2	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004	0/2/0	0.12/0.004
Subtotal				9.13/0.332		9.13/0.332		9.13/0.332		11.29/0.403		11.29/0.403
Controls	At Data Proc.	I	1/0/1	6.78/0.246	1/0/1	6.78/0.216	1/0/1	6.78/0.246	1/0/1	6.90/0.246	1/0/1	6.90/0.246
	Jet Cont. E	I	1/0/1	0.12/0.004	1/0/1	0.12/0.004	1/0/1	0.12/0.004	1/0/1	0.12/0.004	0/0/2	0.00/0.000
	Driver E	I	2/0/0	0.03/0.001	2/0/0	0.03/0.001	2/0/0	0.03/0.001	2/0/0	0.03/0.001	2/0/0	0.03/0.001
	Star Sensor	I	1/0/0	1.27/0.046	1/0/0	1.27/0.046	1/0/0	1.27/0.046	1/0/0	1.29/0.046	1/0/0	1.29/0.046
Subtotal				8.19/0.298		8.19/0.298		8.19/0.298		8.34/0.298		8.22/0.294
Propulsion	Jet Valves	R	0/6/0	0.00/0.000	0/6/0	0.00/0.000	0/6/0	0.00/0.000	1/5/0	17.80/0.636	0/6/0	0.00/0.000
	Latch Valves	R	0/4/0	0.00/0.000	0/4/0	0.00/0.000	0/4/0	0.00/0.000	0/4/0	0.00/0.000	0/4/0	0.00/0.000
	RJet Htr R14	R	2/0/0	0.57/0.021	2/0/0	0.57/0.021	2/0/0	0.57/0.021	2/0/0	0.59/0.021	2/0/0	0.59/0.021
	RJet Htr R23	R	2/0/0	3.36/0.122	2/0/0	3.36/0.122	2/0/0	3.36/0.122	2/0/0	3.48/0.124	2/0/0	3.48/0.124
	AJet Htr A5	R	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	1/0/0	0.86/0.031
	AJet Htr A6	R	1/0/0	1.14/0.041	1/0/0	1.14/0.041	1/0/0	1.14/0.041	1/0/0	1.16/0.042	1/0/0	1.18/0.042
	Prop. Tnk Htrs	R	1/0/1	16.71/0.608	1/0/1	16.71/0.608	1/0/1	16.71/0.608	1/0/1	17.30/0.620	1/0/1	17.36/0.620
Subtotal				21.78/0.792		21.78/0.792		21.78/0.792		40.41/1.443		23.47/0.838
Probes	L. P. Htr	R	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000
	S. P. Htrs	R	0/0/3	0.00/0.000	0/0/3	0.00/0.000	0/0/3	0.00/0.000	0/0/3	0.00/0.000	0/0/3	0.00/0.000
	Ck. O. Pwr-C/DI	I	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000
	Ck. O. Pwr-Sel.	I	0/0/1	0.00/0.000	0/0/1	00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000
	Cmd. Inhibit	R	4/0/0	0.13/0.015	3/0/1	.32/0.011	3/0/1	0.32/0.011	0/0/4	0.00/0.000	0/0/4	0.00/0.000
Subtotal				0.13/0.015		.32/0.011		0.32/0.011		0.00/0.000		0.00/0.000
Power	Batt Charge	R	0/2/0	0.00/0.000	0/2/0	.00/0.000	0/2/0	0.00/0.000	0/2/0	0.00/0.000	2/0/0	9.80/0.350
	Bus Limiter	R	0/5/0	0.76/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025	0/5/0	0.70/0.025
	Under/Over Sw.	R	1/0/0	0.36/0.013	1/0/0	0.38/0.013	1/0/0	0.35/0.013	1/0/0	0.36/0.013	1/0/0	0.36/0.013
	Current Sensor	R	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010	3/0/0	0.28/0.010
	Pwr Interface	R	1/0/0	0.19/0.007	1/0/0	0.19/0.007	1/0/0	0.19/0.007	1/0/0	0.20/0.007	1/0/0	0.20/0.007
	Batt Dischg.	R	0/2/0	1.51/0.055	2/0/0	1.65/0.060	2/0/0	1.51/0.055	0/2/0	1.40/0.050	0/2/0	1.40/0.050
Subtotal				3.01/0.110		3.18/0.115		3.04/0.110		2.94/0.105		12.74/0.455
Distribution Loss				3.17		3.17		2.47		2.93		4.48/
S/C Total				150.03/5.335		150.08/5.336		107.18/3.806		129.13/4.506		166.92/5.772
Science		R	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	0/0/1	0.00/0.000	1/0/0	30.00/1.071
Total S/C Loads				150.03/5.335		150.06/5.336		106.18/3.806		129.13/4.506		196.92/6.893
Solar Panel Power				119.13/4.332		75.90/2.760		75.90/2.760		145.39/5.193		236.08/8.431
Solar Panel Contingency				0.000		/0.000		/0.000		/0.687		/1.538
Battery Amps Used				/1.003		/2.576		/1.046		0.000		/0.000
Battery Amperes Required				1.012 Amps		5.152 Amps		2.092 Amps		0.000 Amps		0.000 Amps
Battery Discharge Depth				26.7 Percent		31.3 Percent		13.9 Percent		0.0 Percent		0.0 Percent

TABLE 4.3.4.4-1

BUS BATTERY CHARGE MANAGEMENT

Mission Phase	Recommended Charge Rate	Recommended Start Time for the Recommended Charge Rate	Comments
Cruise	Low	Continuous	Command to low rate during pre-launch.
Pre-LP Release	High	Approximately 2 days before L. P. release; charge at high rate until roll-over.	Approximately 2 hours; this maximizes capacity for pyro firings.
Pre-LP Release Reorientation	Low	Approximately 2 days before reorientation for L. P. release.	Go back to low rate charge at least one day before reorientation to minimize star sensor temperature.
Post-LP Release	High	Approximately 2 days before S. P. release; charge at high rate until roll-over.	Approximately 2 hours; this maximizes capacity for pyro firings.
Pre-SP Release	Low	Approximately 2 days before reorientation for S. P. release.	Go back to low rate charge at least one day before reorientation to minimize star sensor temperature.
Post-SP Release	High	After Post-S. P. release attitude achieved; charge at high rate until roll-over.	Batteries may be needed for Bus Targeting if sun angle $<25^{\circ}$.
Pre-Bus Target Reorientation	Low	Immediately after roll-over, above.	Stay in low rate charge for balance of mission.

TABLE 4.3.5.3-1

PROBE CHECKOUT SEQUENCE

1. BUS PREPARATION (REPRESENTATIVE)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
		Representative sequence to produce as final conditions: High power mode (amplifiers 1 & 3) forward omni antenna, Bus Engineering Format, and 16 bps (for other antenna configurations, at high or low power, see Section 3.7.3; for other formats or data rates, use Section 3.6.3). Assumed initial conditions: • Uplink and downlink established with 26 M. Station. • Low power mode, Amplifier 1 • Forward omni antenna. • Data rate = 8 bps. • Arbitrary format. • Power amp 3 connected to 3 dB hybrid.	NOTE: Regarding Bus Voltage Limiter Current, PLIMTI, the value will only change in response to load switching when the limiter is operating.	
1-1	AMP1Ø or AMPAØ	Power amplifier 1 and 2 OFF (No RF power at switch contacts during switching).	Loss of downlink (TM & Carrier)	
1-2	ANT12 or ANTA2	High Power to Forward Omni	No Downlink	
1-3	AMP12 or AMPA2	Amplifier 1 HI Power Select	No Downlink	

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
1-4	AMP19 or AMPA9	Power Amplifier 1 ON	Downlink reappears at 1/2 of original signal strength. Telemetry resumes if signal strength is sufficient for reacquisition.	
			RAMP1W	RF Power Output 1 = 10W.
			PBUSLI	Spacecraft Loads Current, Δ = +1.5A.
			PLIMTI	Bus Voltage Limiter Current, Δ = -1.5A.
1-5	AMP39 or AMPC9	Power Amplifier 3 ON.	Downlink signal strength increases by 6 dB.	
			RAMP3W	RF Power Output 3 = 10W.
			PBUSLI	Spacecraft Loads Current, Δ = +1.5A.
			PLIMTI	Bus Voltage Limiter Current, Δ = -1.5A.
1-6A	MIH21 or MIHB1	Probes High Mod Index Select	N/A	None
OR	OR			
1-6B	MIL21 or MILB1	Probes Low Mod Index Select	N/A	None

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
1-7	TPCQ1 or TPCQA	TP Control: a) Bus Engineering Format Select (Not required if already in this format).	Internal Word 3	Format Designation
		b) 16 bps Select.	Internal Word 3	Data Rate Designation.
1-8	PCO19 or PCOA9	Probes checkout power ON.	PCHEKS	Probe Checkout Power ON/OFF
			PBUSL1	Spacecraft Loads Current, A = 0.0 (1.4 mA)

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TABLE 4.3.5.3-1

PROBE CHECKOUT SEQUENCE (Continued)

2. PROBE PREPARATION (REPRESENTATIVE)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
2A		Large Probe Sequence resulting in descent format and 256 bps (See Section 5.1.2 for alternate formats and/or data rate).		
2A-1		Verify probe shelf temperatures are above minimum operating limit of -4°F.	SLAF1T	LP Aft Shelf Temperature
			SLFW1T	LP Fwd Shelf Temperature
2A-2	LCD19	Command/Data Unit Power Relay ON.	PBUSLI	Spacecraft Loads Current, Δ = +0.2A
			PLIMTI	Spacecraft Loads Current, Δ = -0.2A
			PLBUSI	LP Bus Current, Δ = +0.2A
			PLCD1S	C/DU Power Relay 1 ON/OFF = 1
			PLCD2S	C/DU Power Relay 2 ON/OFF = 2
				ID, Format Status = 00 (Descent Format)
				ID, Data Rate Status = 1 (256 bps)
				ID, Stored Data ON/OFF = 1
				Large Probe TM Subcarrier appears on Downlink.
			NOTE (1): The Probe Spacecraft are designed to prevent the inadvertent starting of the Entry Sequence Programmer (ESP) while the probes are attached to the Bus. This feature is accomplished by means of an inhibiting voltage supplied by the Bus to each probe via the IFD. This voltage not only inhibits the ESP, but also enables the probe subcarrier for checkout. This means that during probe checkout, when the C/DU is turned ON, one must immediately check for a probe subcarrier. If none is found, it has to be assumed that the inhibit (Continued)	

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
2A-2 (Continued)			signal has failed and the C/DU must be turned off as quickly as possible. For the small probes, the sequence may proceed for 1020 seconds before an irreversible command is issued but for the large probe, an irreversible command LGC TIV activate is issued 5.75 seconds after turn-on. Fortunately, this command initiates a thermally actuated event which has about a one-minute delay time. If the unit is turned off before the one minute elapses, no damage will have occurred. To safely checkout the large probe, it will be necessary to devise a short sequence to load into the command memory that turns on the C/DU and turns off the science power primary relay and the LGC instrument until a probe subcarrier can be verified. It may be useful to operate both large and small probes under control of the memory and have the C/DU turned off at a predetermined time if there is no subcarrier and/or the uplink fails. NOTE (2): The Probe Data Memory will automatically commence the storing of data upon CDU power turn ON. The memory will always contain the six minor frames preceding the Stored Data Off command. When a Stored Data Off command is sent to the Probe Data Memory, the data word being stored at the time will have all but it's last bit stored. That particular bit position will be old previously stored data. Therefore, the 64th word of the sixth minor frame readout of the Probe Data Memory will be in error. The Probe Data Memory responds to the Memory Readout words in any of the minor frame formats that have such words irrespective of whether the Probe Data Memory is in the Stored Data On or Stored Data Off mode. All data words readout of the memory are recirculated into the start of the memory. (Continued)	

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TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
2A-2 (Continued)			Bit 0 of the fourth data word of each minor frame contains the Data Storage Mode indicator. Whenever a logic one appears in this bit position, it should be construed that Memory Read Out words within such frames will contain older, recirculated data that is out of sequence with the other data words contained in the same frame. It may be worthwhile to attempt a reconstruction of such data.	
2B		Small Probe X, X = 1, 2, 3. Sequence resulting in upper descent format and 64 bps (See Section 5.2.2 for alternate formats and/or data rate).		
2B-1		Verify probe shelf temperatures are above minimum operating limit of -4°F.	SXAF1T	SP X Aft Shelf Temperature.
			SXFW1T	SPX Fwd Shelf Temperature.
2B-2	SCDX9	SP X C/DU and RF Power Relay ON.	PBUS1J	Spacecraft Loads Current, Δ = +0.4A
			PLIMT1	Bus Voltage Limiter Current, Δ = -0.4A
			PXBUS1	SP X Bus Current, Δ = +0.4A
			PXCD1S	SP X C/DU and RF Power Relay 1 ON/OFF = 1
			PXCD2S	SP X C/DU and RF Power Relay 2 ON/OFF = 1
				ID, Format Status = 0 (Upper Descent Format)
				ID, Data Rate Status = 1 (64 bps)
				ID, Stored Data ON/OFF = 1
		The Notes in Step 2A-2 apply for the Small Probes, here, as well.		Small Probe X TM Subcarrier appears on Downlink.

TABLE 4.3.5.3-1 (Continued)

3. Functional Checkout (Representative)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION TLM MNEMONIC	TLM TITLE
3A		Large Probe		
3A-1	LRC19	Receiver ON	PLRCVS	Receiver ON/OFF = 1
			RLVCOT	Receiver VCO Temp. (Settles at TBD° F)
			RLAGCV	Receiver AGC Voltage = TBD
			RLSPEV	Receiver Static Phase Error = TBD
			PLBUSI	LP Bus Current, Δ = +0.1A
			PBUSLI	Spacecraft Loads Current, Δ = +0.1A
			PLIMTI	Bus Voltage Limiter Current, Δ = -0.1A
3A-2	LRC1Ø	Receiver OFF.	PLRCVS	Receiver ON/OFF = 0.
			RLVCOT	Receiver VCO Temp. (Settles at TBD° F).
			RLAGCV	Receiver AGC Voltage = 0.0.
			RLSPEV	Receiver Static Phase Error = 0.0
			PLBUSI	LP Bus Current, Δ = -0.1A
			PBUSLI	Spacecraft Loads Current, Δ = -0.1A
			PLIMTI	Bus Voltage Limiter Current, Δ = +0.1A.
3A-3	LRF19	RF Power Relay ON.	PLRFRS	RF Power Relay ON/OFF = 1
			RLOSCT	XMTR Aux. Oscillator Temp. (Settles at TBD°F).
			PLBUSI	LP Bus Current Δ = +6.4A
			PBUSLI	S/C Loads Current, Δ = +6.4A.
			PLIMTI	Bus Voltage Limiter Current, Δ = -6.4A

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
3A-4	LRF1Ø	RF Power Relay OFF (RF Power ON duration limited to TBD Minutes).	PLRFRS	RF Power Relay ON/OFF = 0.
			RLOSCT	XMTR Aux. Osc. Temp. TBD° F.
			PLBUSI	LP Bus Current, Δ = -6.4A
			PBUSLI	Spacecraft Loads Current, Δ = +6.4A
			PLIMTI	Bus Voltage Limiter Current, Δ = +6.4A.
3A-5	LSC29	Science Power Backup Relay ON. (Short Hi-Current Transient; not likely detectable).	PLSP2S	Science Power Backup Relay ON/OFF = 1.
3A-6	LSC2Ø	Science Power Backup Relay OFF.	PLSP2S	Science Power Backup Relay ON/OFF = 0.
3A-7	LSC19	Science Power Primary Relay ON. (Perform scientific instrument checkout as required).	PLSP1S	Science Power Primary Relay ON/OFF = 1.
3A-8	LSB1Ø	Subcarrier OFF.		ID, Data ON/OFF = 0. Loss of probe TM Subcarrier on downlink.
3A-9	LBR13	Data Rate 128 bps Select.		ID, Bit Rate Status Resumption of probe TM subcarrier on downlink.
3A-10	LFM12	Blackout Format Select.		ID, Format Status = 01.
3A-11	LTS1Ø	Stored Data OFF (Stored Data ON by initial conditions).		ID, Stored Data ON/OFF = 0.
3A-12	LTS19	Stored Data Initiate.		ID, Stored Data ON/OFF = 1.
3A-13	LBR14	Data Rate 256 bps Select.		ID, Bit Rate Status = 1.
3A-14	LFM11	Descent Format Select.		ID, Format Status = 00.
3A-15	LSC1Ø	Science Power Primary Relay OFF.	PLSP1S	Science Power Primary Relay ON/OFF = 0.
3A-16	LCD1Ø	Command/Data Unit Power Relay OFF.	PBUSLI	S/C Loads Current, Δ = -3.0A.
			PLIMTI	Bus Limiter Current, Δ = +0.3A.
				Loss of Probe Subcarrier on Downlink.

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
3B		Small Probe X, X = 1, 2 or 3.		
3B-1	SOSX9	SPX Stable Oscillator ON. (If not already ON for 25 day "bakeout" period starting at E-45 days).	PXOSCS	SPX Stable Oscillator ON/OFF = 1.
			PXBUSI	SPX Bus Current, Δ = +0.20A.
			PLBUSI	Spacecraft Load Current, Δ = +0.20A.
			PLIMTI	Bus Voltage Limiter Current, Δ = -0.20A.
3B-2	SAMX9	SPX Power Amplifier ON.	PXBUSI	SPX Bus Current, Δ = +1.64A.
			PLBUSI	Spacecraft Load Current, Δ = +1.6A
			PLIMTI	Bus Voltage Limiter Current, Δ = -1.6A.
3B-3	SAMXØ	SPX Power Amplifier OFF/Stable Oscillator OFF (Amplifier On-Time limited to TBD Minutes). (Stable Oscillator must be turned back ON if "bakeout" period is in progress)	PXOSCS	SPX Stable Oscillator ON/OFF = 0.
			PXBUSI	SPX Bus Current, Δ = -1.6A
			PLBUSI	Spacecraft Load Current, Δ = -1.6A.
			PLIMTI	Bus Voltage Limiter Current, Δ = +1.6A.
3B-4	SSCX9	SPX Science Power Primary Relay ON (Short duration hi-current transient; not likely detectable (Perform scientific instrument checkout as req'd).	PXSP1S	SPX Science Power Primary Relay ON/OFF = 1.
3B-5	SFMX2	SPX Blackout Format		ID, Format Status = 01.
3B-6	STSXØ	SPX Stored Data OFF (Stored Data ON by initial conditions - There is no access to stored data initiate command).		ID, Stored Data ON/OFF = 0.
3B-7	SFMX1	SPX Lower Descent Format		ID, Format Status = 11.
3B-8	SBRX1	SPX Data Rate 16 bps Select.		ID, Bit Rate Status = 0.
3B-9	SSCXØ	SPX Science Power Primary Relay OFF.	PXSP1S	SPX Science Power Primary Relay ON/OFF = 0.

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
3B-10	SCDXØ	SPX C/DU and RF Power Relay OFF.	PBUSLI	Spacecraft Loads Current, Δ = -0.4A
			PLIMTI	Bus Voltage Limiter Current, Δ = +0.4A.
				Loss of probe Subcarrier on downlink.

4. PROBE RECONFIGURATION

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
4A		Large Probe		
4A-1		Turn OFF any active power relays including:		
	LRC1Ø	Receiver OFF	PLRCVS	Receiver ON/OFF = 0
			RLVCOT	Receiver VCO Temp. (Settles at TBD°F).
			RLAGCV	Receiver AGC Voltage = 0.0
			RLSPEV	Receiver Static Phase Error = 0.0.
			PLBUSI	LP Bus Current, Δ = -0.1A.
			PBUSLI	S/C Loads Current, Δ = -0.1A.
			PLIMTI	Bus Voltage Limiter Current, Δ = +0.1A
	LRF1Ø	RF Power Relay OFF	PLRFRS	RF Power Relay ON/OFF = 0.
			RLOSCT	Xmtr Aux. Osc. Temp (Settles at TBD°F).
			PLBUSI	LP Bus Current, Δ = -6.4A.
			PBUSLI	S/C Loads Current, Δ = -6.4A.
			PLIMTI	Bus Voltage Limiter Current, Δ = +6.4A.
	LSC2Ø	Science Power Backup Relay OFF	PLSP2S	Science Power Backup Relay ON/OFF = 0.
	LSC1Ø	Science Power Primary Relay OFF	PLSP1S	Science Power Primary Relay ON/OFF = 0.

TABLE 4.3.5.3-1 (Continued)

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION TLM MNEMONIC	TLM TITLE
4A-2	LCD1Ø	Command/Data Unit Power Relay OFF	PBUSLI	Spacecraft Loads Current, Δ = -0.3A
			PLIMTI	Bus Limiter Current, Δ = +0.3A.
				Loss of Probe Subcarrier on ground.
4B		Small Probe X		
4B-1		Turn OFF any active power relays including:		
	SAMXØ	SPX Power Amplifier OFF/Stable Oscillator OFF. (Stable Oscillator must turned back ON if "bakeout" period is in progress).	PXOSCS	SPX Stable Oscillator ON/OFF = 0
			PXBUSI	SPX Bus Current, Δ = -1.6A.
			PLBUSI	Spacecraft Load Current, Δ = +1.6A.
			PLIMTI	Bus Voltage Limiter Current, Δ = -1.6A.
	SSCXØ	SPX Science Power Primary Relay OFF.	PXSP1S	SPX Science Power Primary Relay ON/OFF.
4B-2	SCDXØ	SPX C/DU and RF Power Relay OFF.	PBUSLI	Spacecraft Loads Current, Δ = -0.4A.
			PLIMTI	Bus Voltage Limiter Current, Δ = +0.4A.
				Loss of Probe Subcarrier on ground.

TABLE 4.3.5.3-1 (Continued)

5. POST-CHECKOUT RETURN TO INITIAL CONDITIONS

STEP NUMBER	COMMAND MNEMONIC	COMMAND TITLE OR EVENT	TELEMETRY VERIFICATION	
			TLM MNEMONIC	TLM TITLE
5-1	PCO1Ø or PCOAØ	Probe Checkout Power OFF (Delete this command if Small Probes' Stable Oscillators "bakeout" period is in progress).	PCHEKS	Probe Checkout Power ON/OFF = 0.
5-2	AMP1Ø or AMPAØ	Power Amplifiers 1 and 2 OFF.		
	AMP3Ø or AMPCØ	Power Amplifiers 3 and 4 OFF (No RF power at switch contacts during switching)	Loss of downlink.	
5-3	ANT11 or ANTA1	Low Power to Fwd Omni Select.	No downlink.	
5-4	AMP11 or AMPA1	Amplifier 1 to Low Power Select.	No downlink.	
5-5	AMP19 or AMPA9	Power Amplifier 1 ON.	Downlink signal reappears at low power mode level.	
			RAMP1W	RF Power Output 1 = 10 W.
			PBUSLI	S/C Loads Current, Δ = +1.5A.
			PLIMTI	Bus Volt. Lim. Current, Δ = -1.5A.
5-6	TPCQ1 or TPCQA	TP Control: a) Select Initial format - No action if Bus Engineering Format.	Internal Word 3	Format Designation.
		b) 8 bps Select.	Internal Word 3	Data Rate Designation.

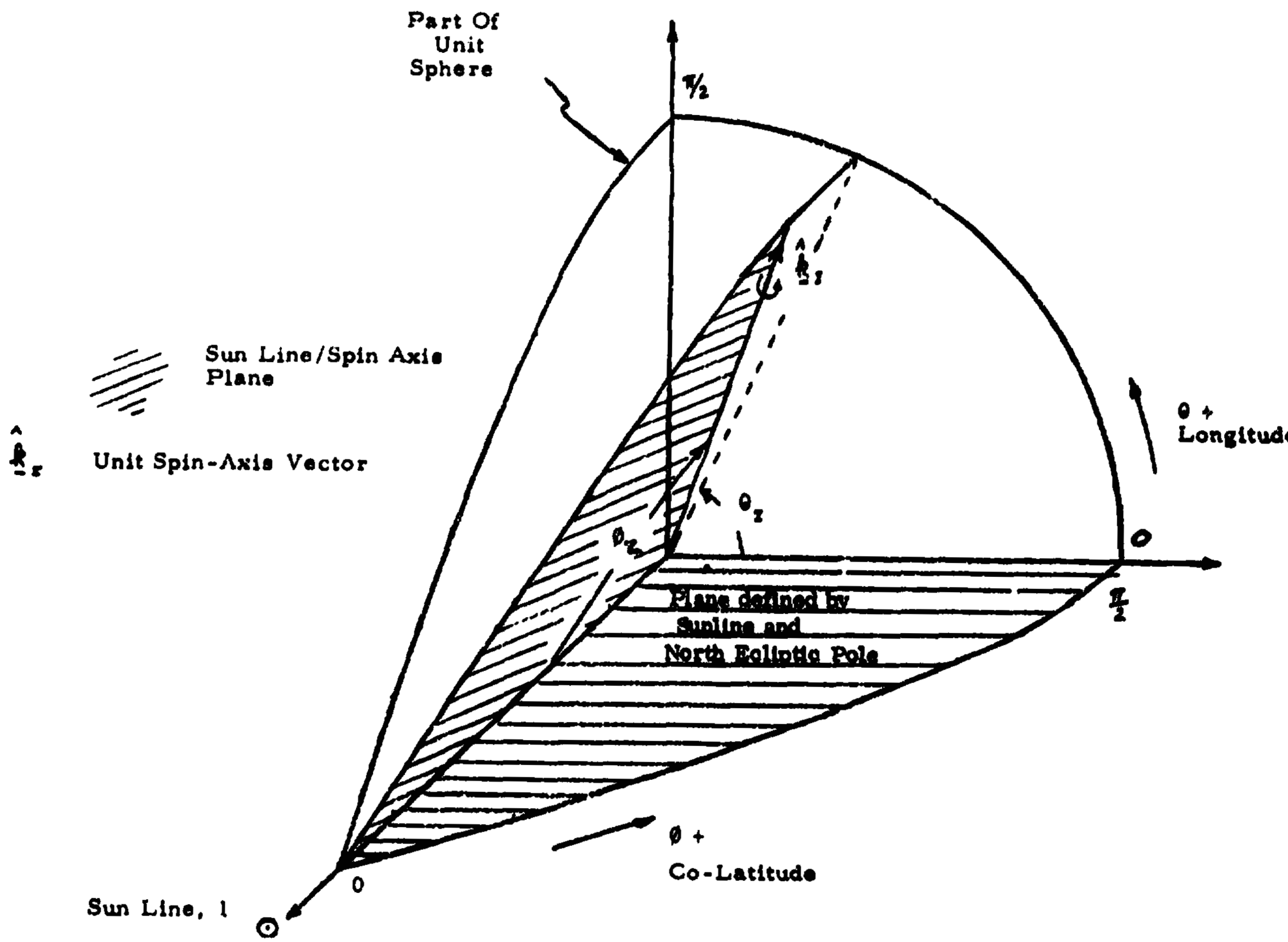

Figure 4.3.1.4.1-1. Spacecraft-Centered Inertial Frame and Definitions of Angles ø and θ

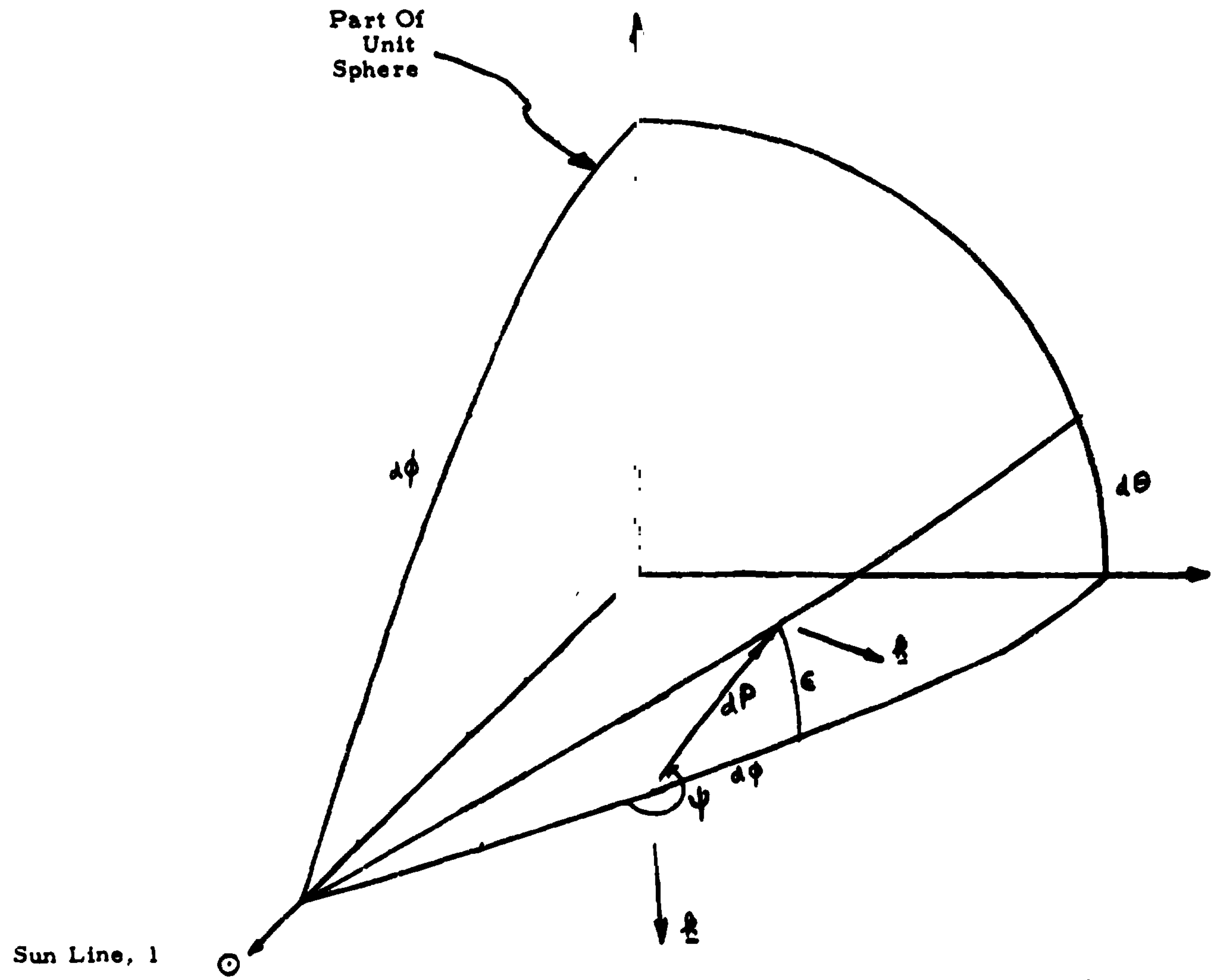

Figure 4.3.1.4.1-2. Schematic of Infinitesimal Precession of Spin Axis

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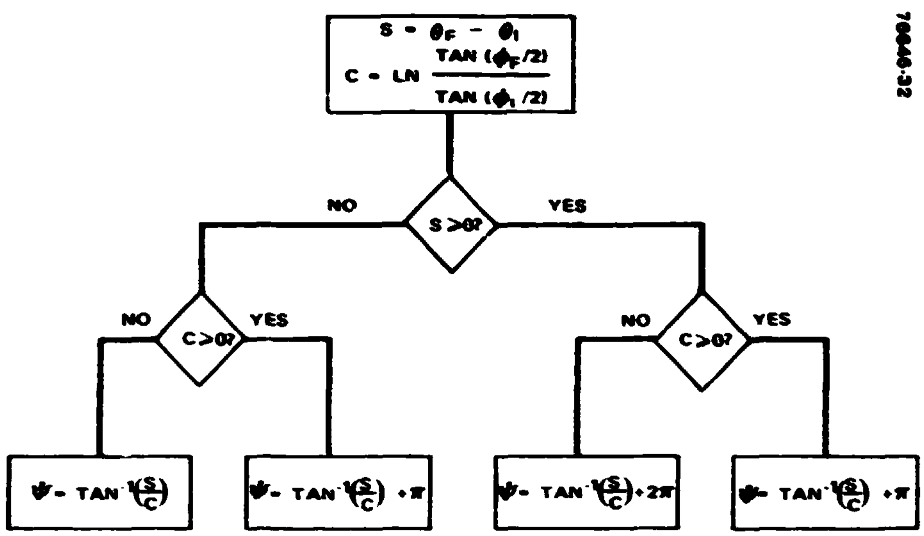
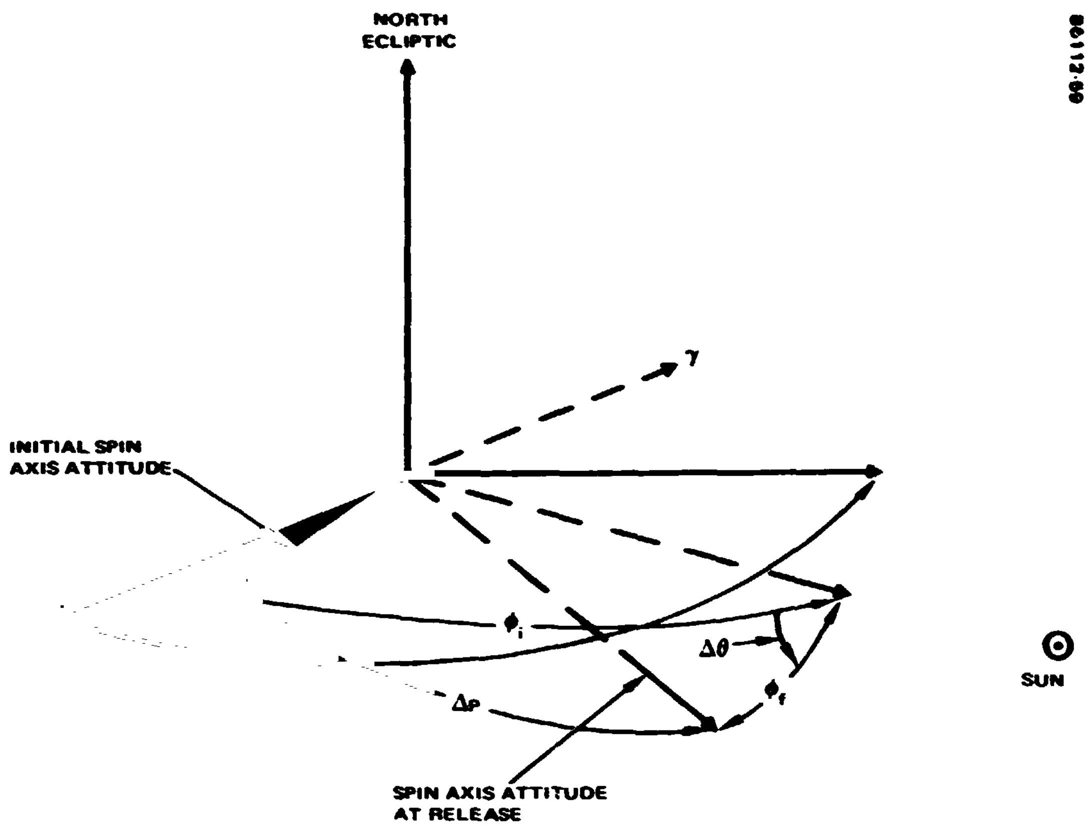


FIGURE 4.3.1.4.2-1. LOGIC FOR DETERMINING PHASE ANGLE, ψ



VECTOR	CELESTIAL LATITUDE, DEG	CELESTIAL LONGITUDE, DEG
SUNLINE	-1.8	244
INITIAL SPACECRAFT ATTITUDE	+15.0	195
NOMINAL SPACECRAFT ATTITUDE AFTER MANEUVER	-15.8	234.5

FIGURE 4.3.1.4.2-2. ATTITUDE GEOMETRY FOR SMALL PROBE RELEASE REORIENTATION

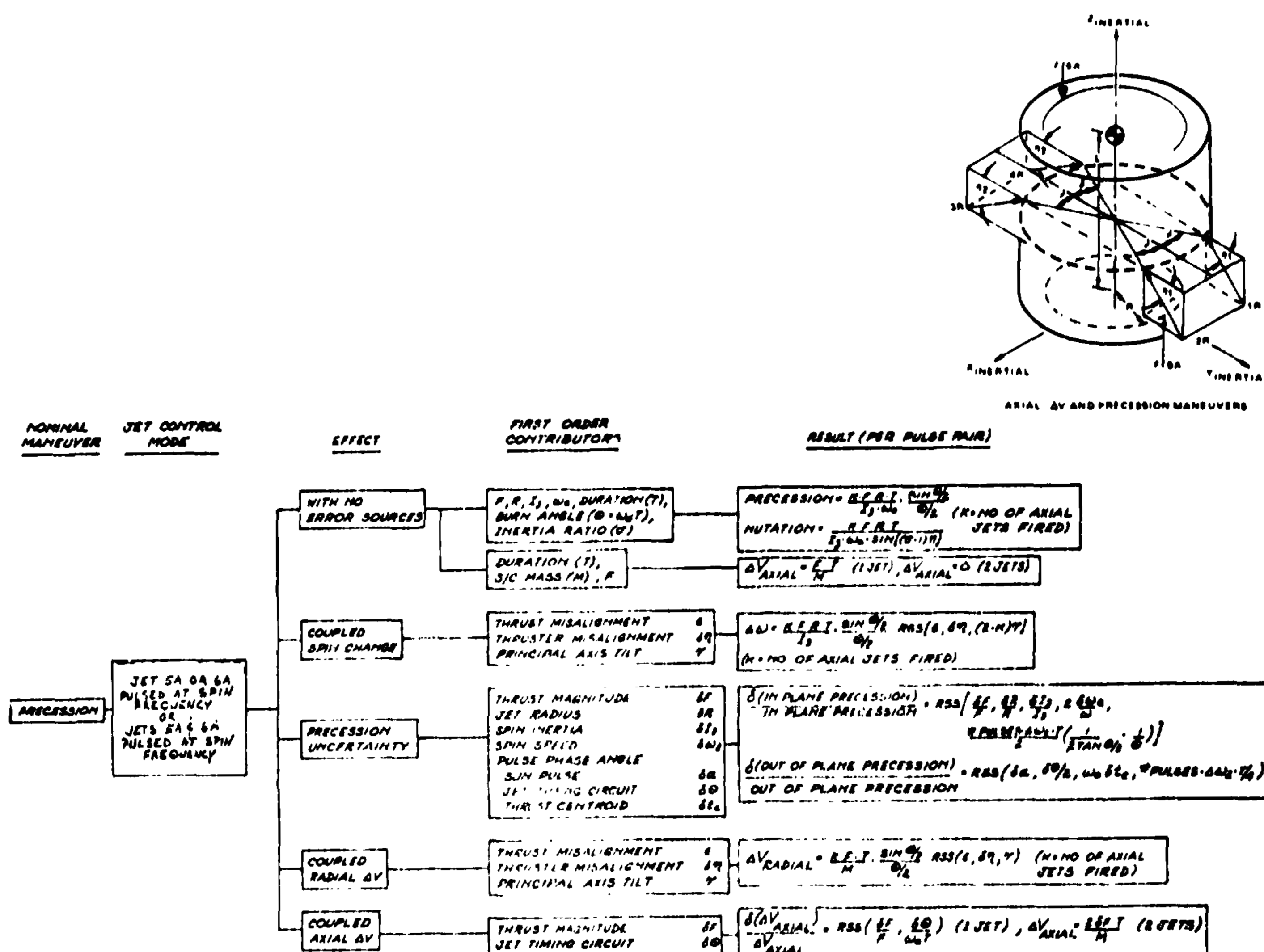


FIGURE 4.3.1.4.2.3-1. PRECESSION MANEUVER ALGORITHMS

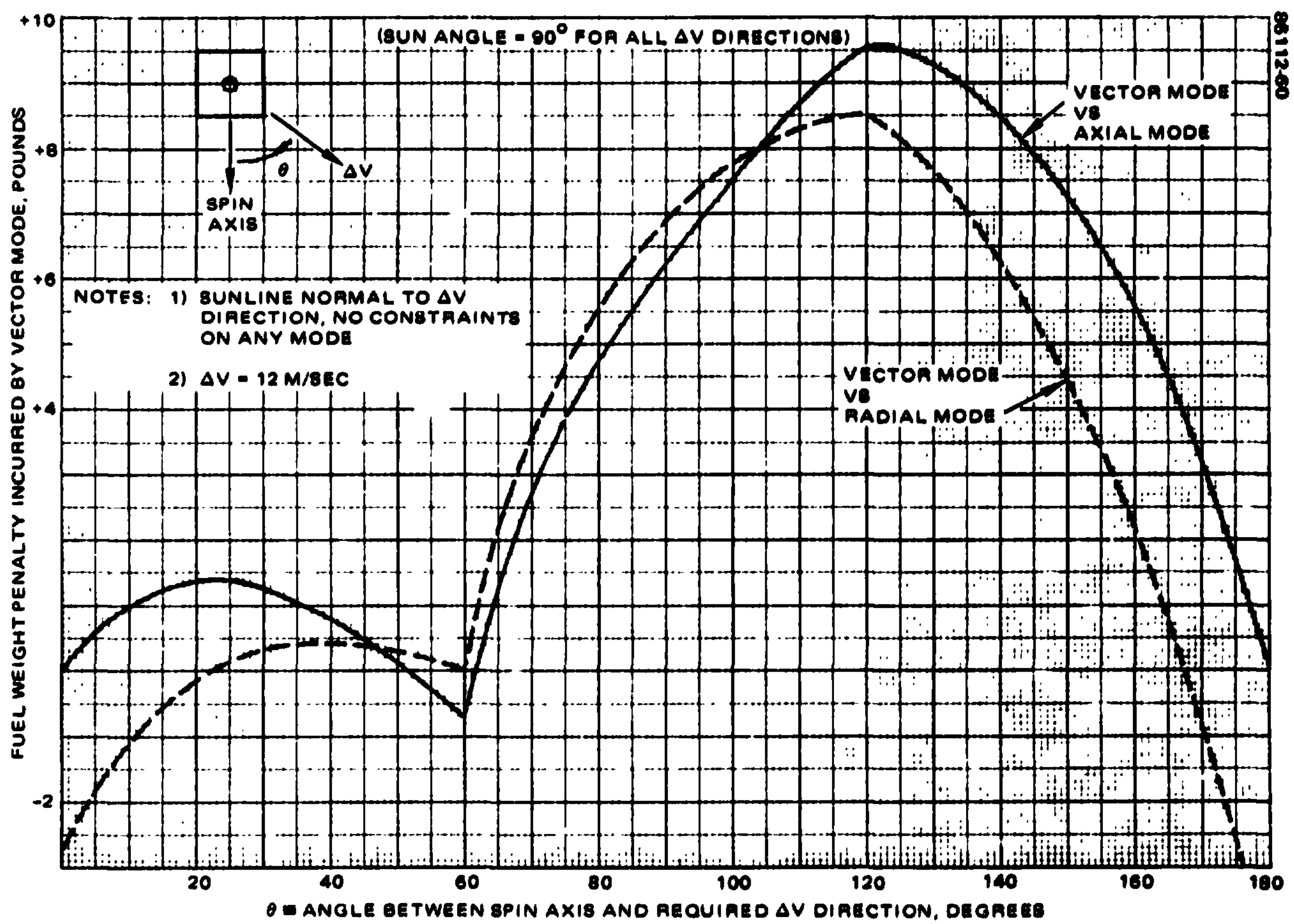


FIGURE 4.3.1.5.1-1. FUEL WEIGHT PENALTY INCURRED BY USE OF VECTOR MODE

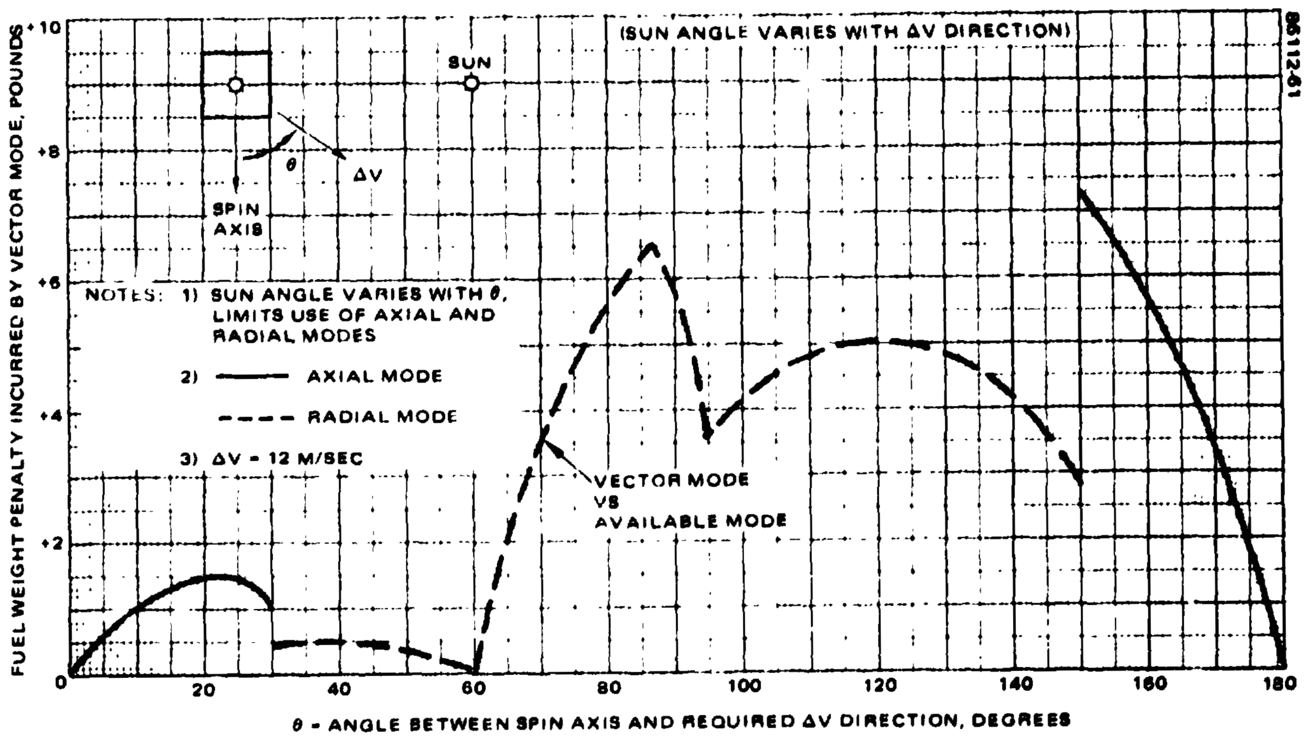


FIGURE 4.3.1.5.1-2. FUEL WEIGHT PENALTY INCURRED BY USE OF VECTOR MODE

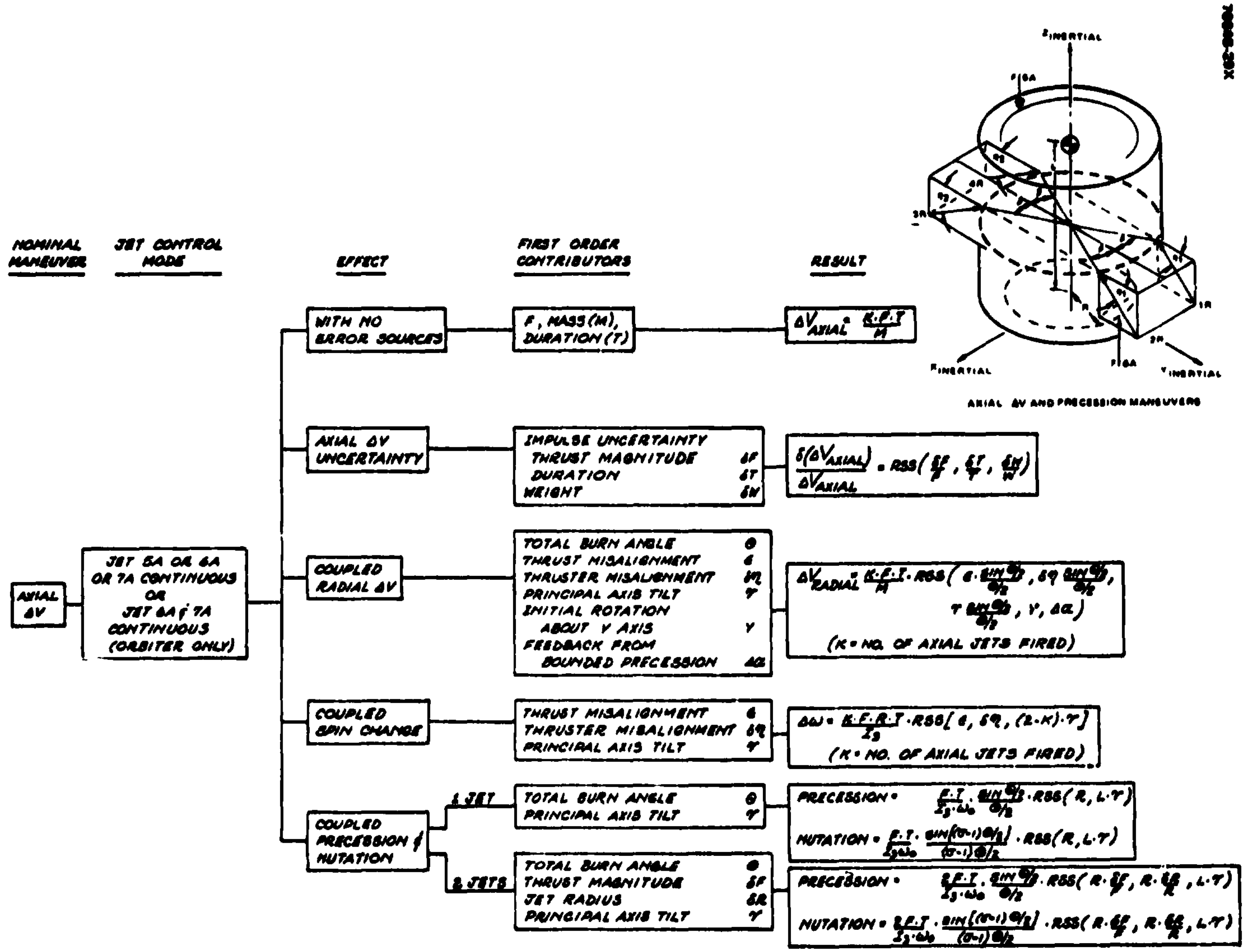


FIGURE 4.3.1.5.2.2-1. AXIAL ΔV MANEUVER ALGORITHMS

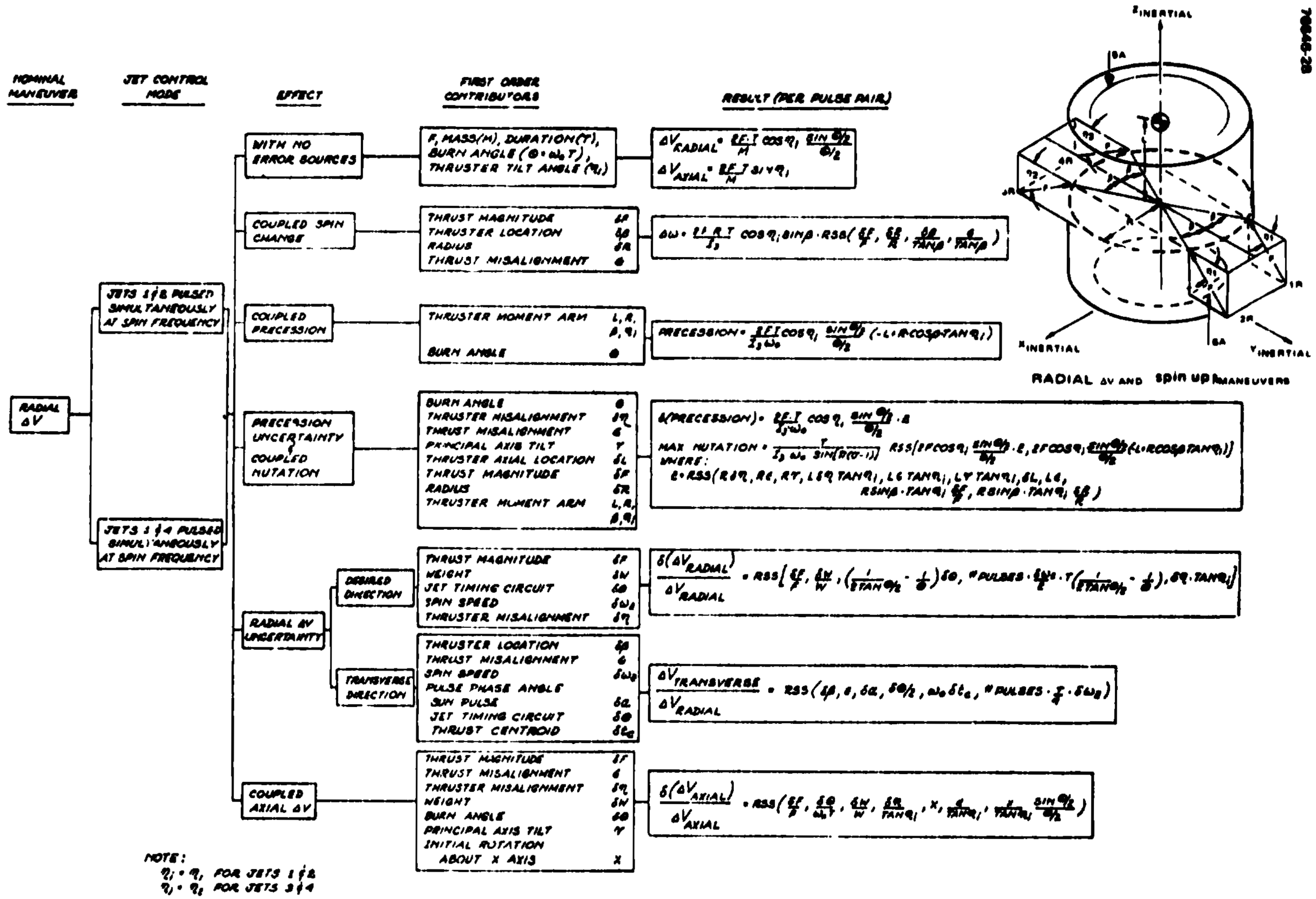


FIGURE 4.3.1.5.2.2-2. RADIAL ΔV MANEUVER ALGORITHMS

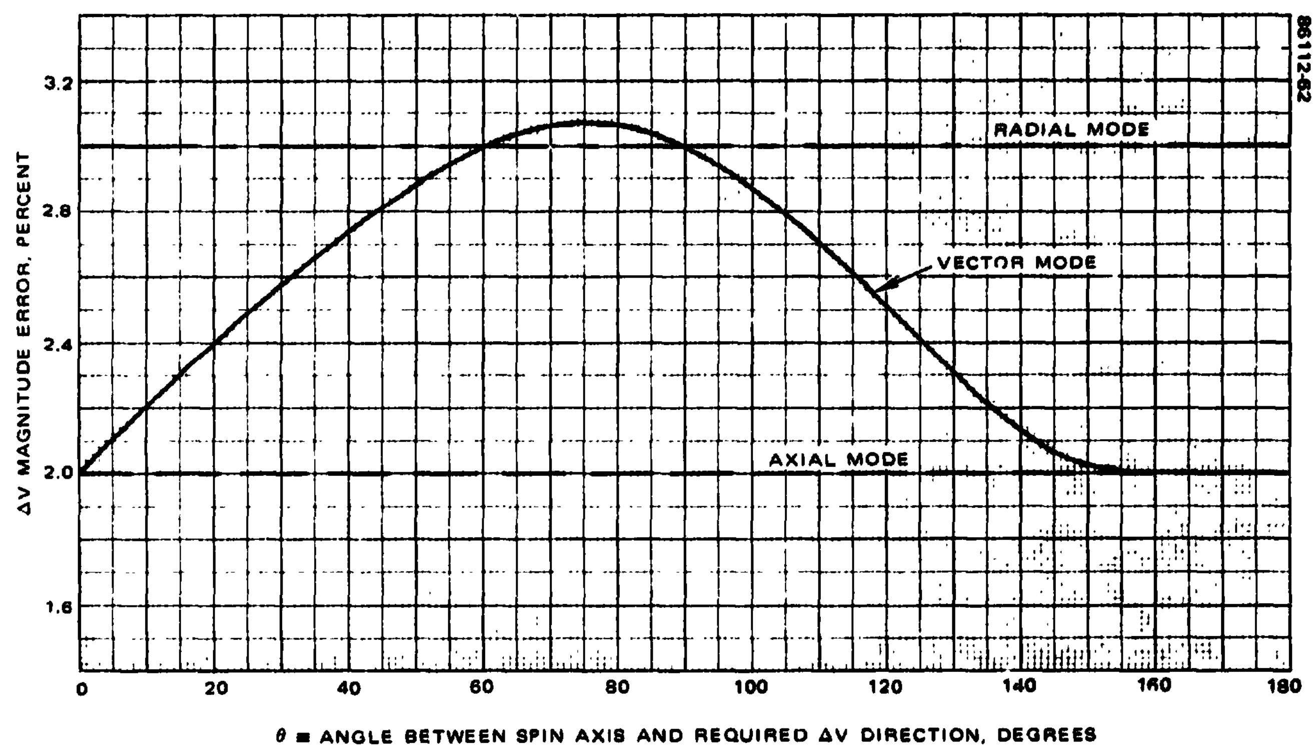


FIGURE 4.3.1.5.2.2-3A. ΔV NOMINAL EXPECTED ERRORS IN MAGNITUDE

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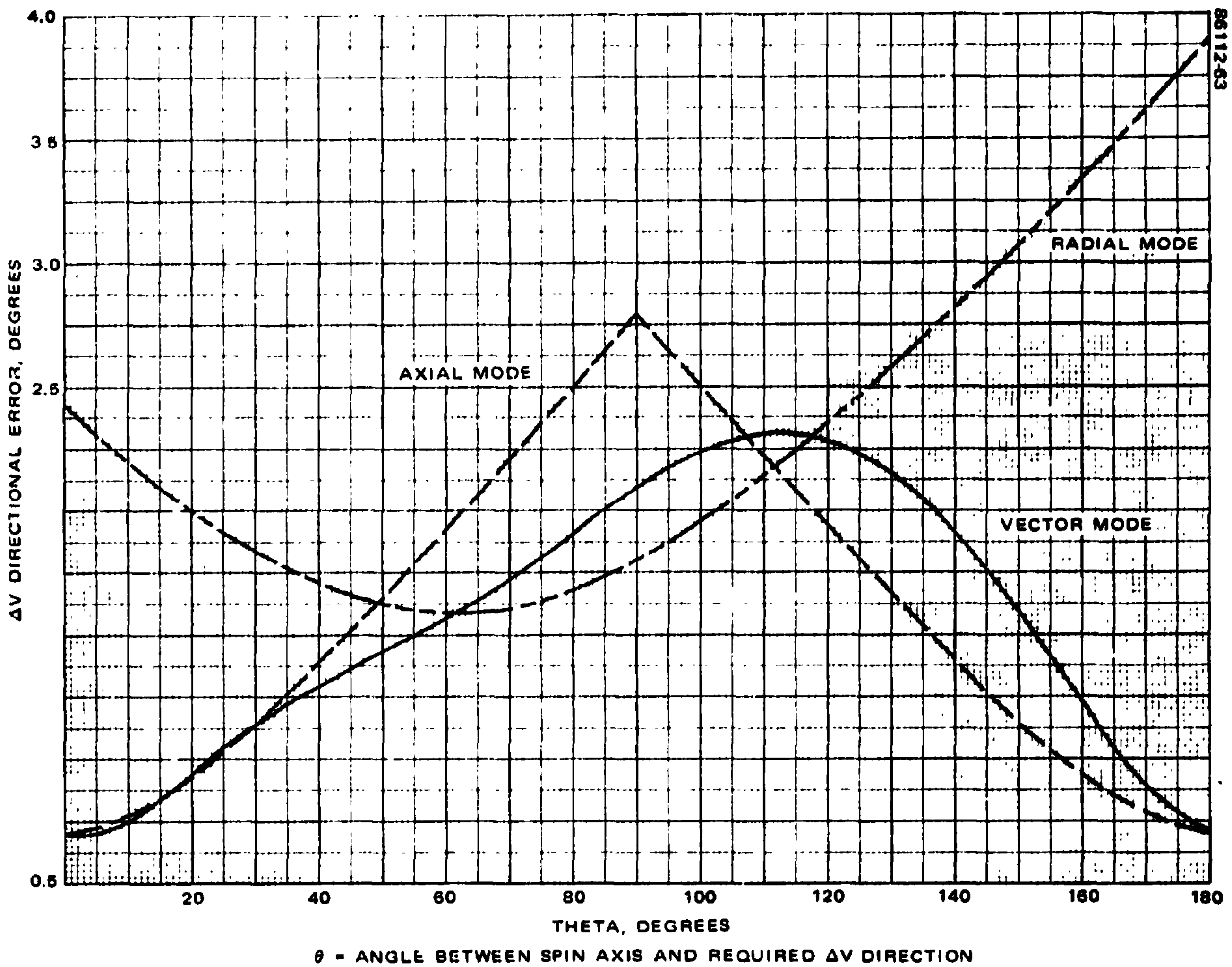

FIGURE 4.3.1.5.2.2-3B. ΔV NOMINAL EXPECTED ERRORS IN DIRECTION

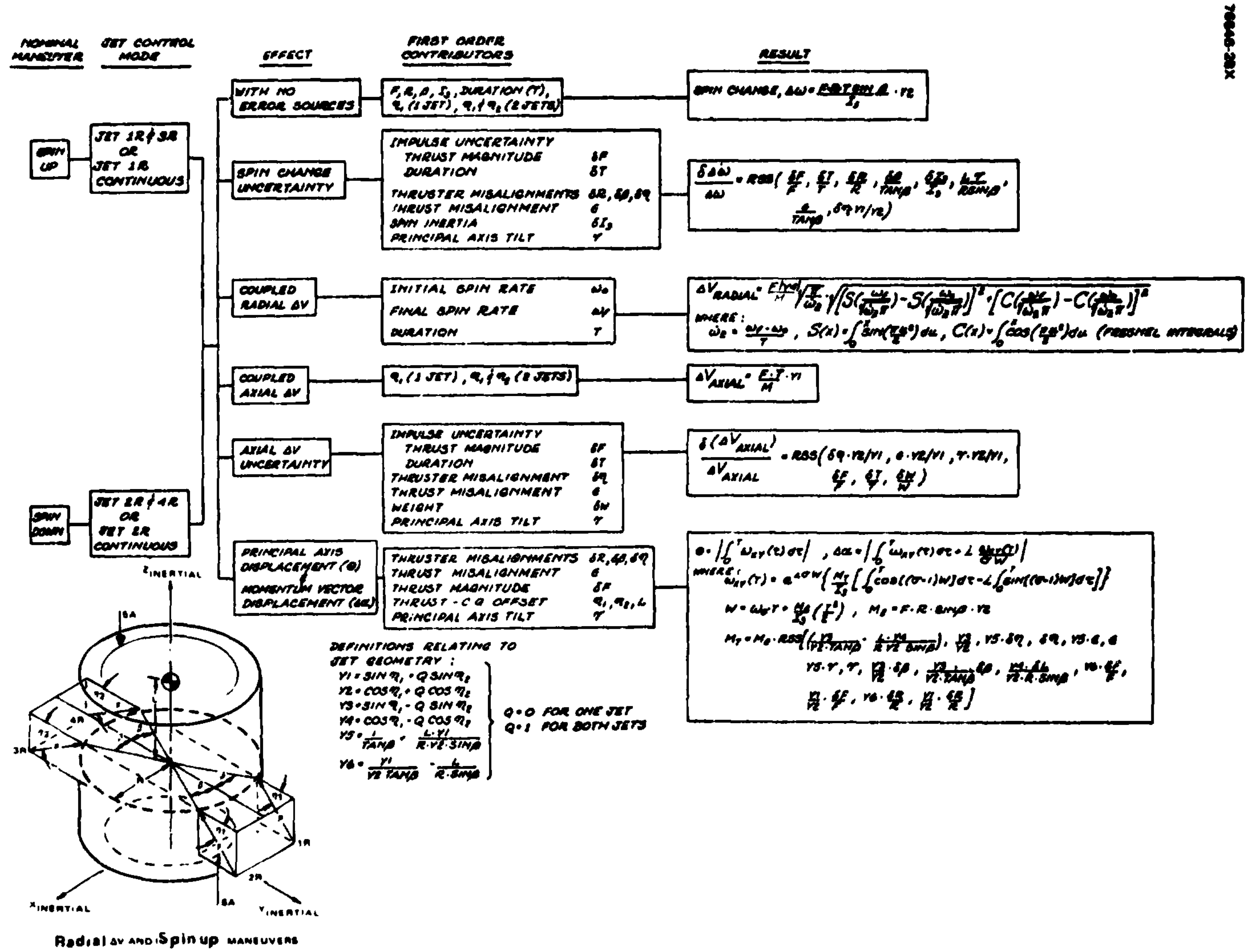

FIGURE 4.3.1.6.2.2-1. SPIN CHANGE MANEUVER ALGORITHMS

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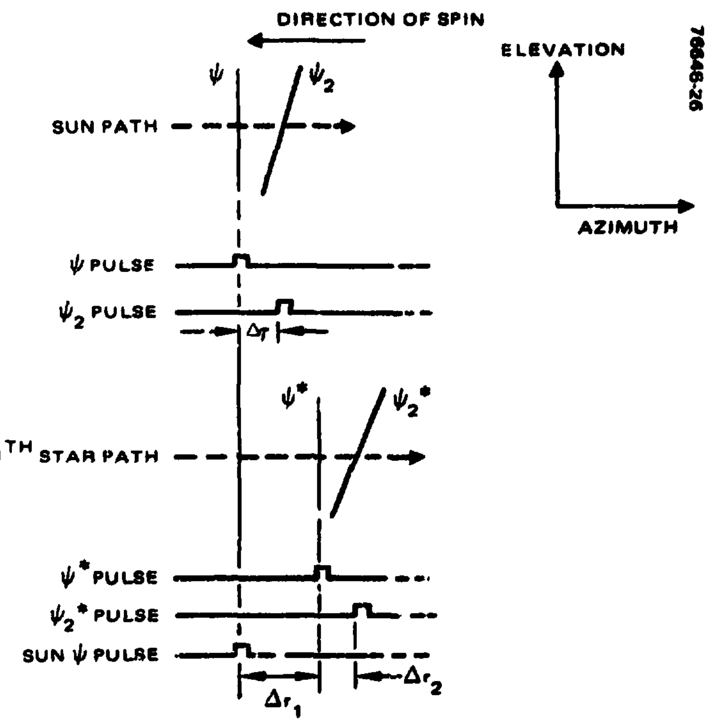
ATTITUDE SENSOR CONFIGURATION

- REDUNDANT DUAL SLIT SUN SENSORS
- SINGLE DUAL SLIT STAR SENSOR, INDEPENDENT ELECTRONIC ASSEMBLIES
- TIME INTERVALS BETWEEN SUN AND STAR PULSES DEFINE ROLL RATE, ASPECT ANGLES, AND SPIN ANGLES

DATA TYPES

- PRIMARY: $\psi\psi_2$, $\psi\psi^*(i)$, $\psi\psi_2^*(i)$
- SECONDARY: $\psi^*(i)\psi_2^*(i)$, $\psi^*(i)\psi^*(j)$, $\psi_2^*(i)\psi_2^*(j)$, $\psi^*(i)\psi_2^*(j)$



NOTE: $\Delta\tau$ MEASURES SUN ASPECT ANGLE γ
$\Delta\tau_1$ MEASURES SUN-STAR ROLL ANGLE A_1
$\Delta\tau_2$ MEASURES STAR ASPECT ANGLE λ_1

FIGURE 4.3.2.3-1. ATTITUD… …NSORS AND DATA TYPES

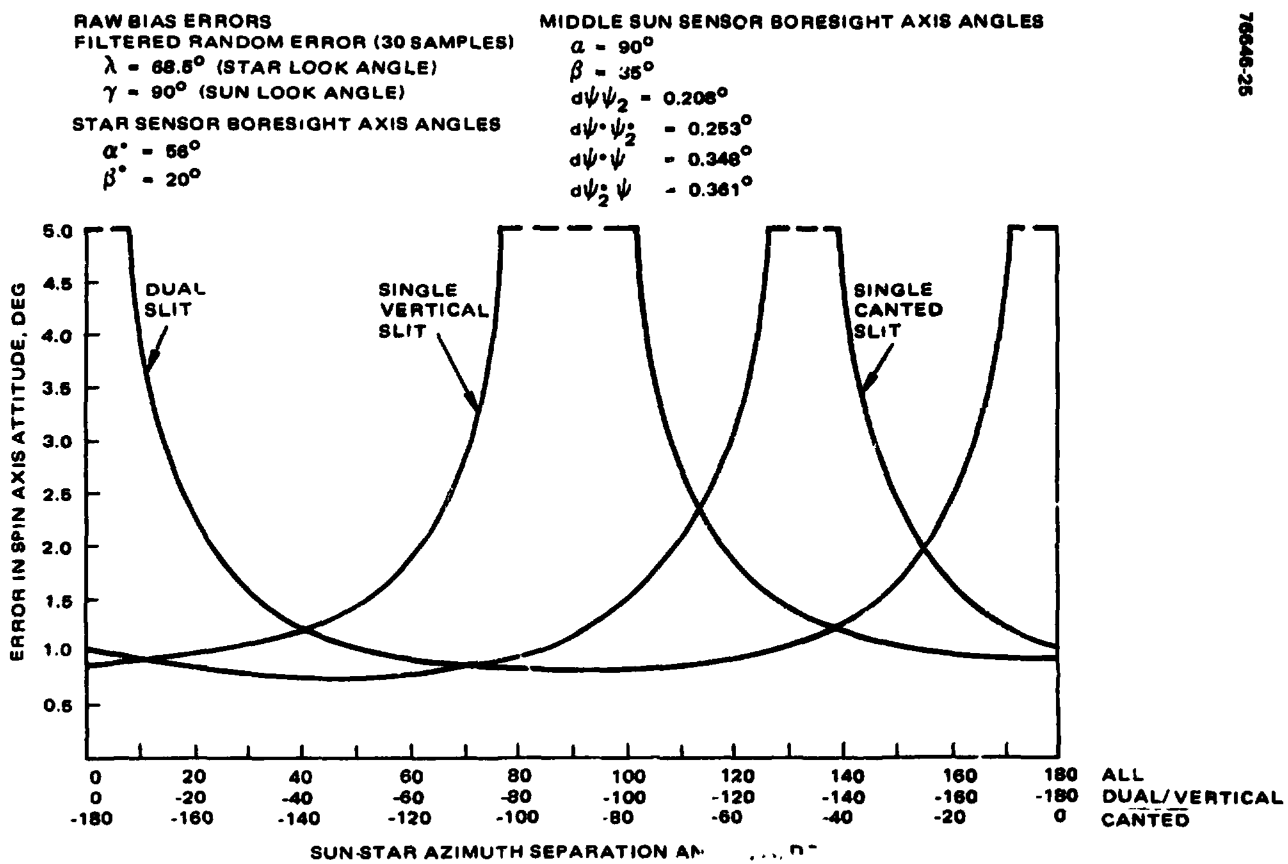


FIGURE 4.3.2.3-2. ATTITUDE DETERMINATIO[illegible] SENSOR SLIT USAGE AND GEOMETRY

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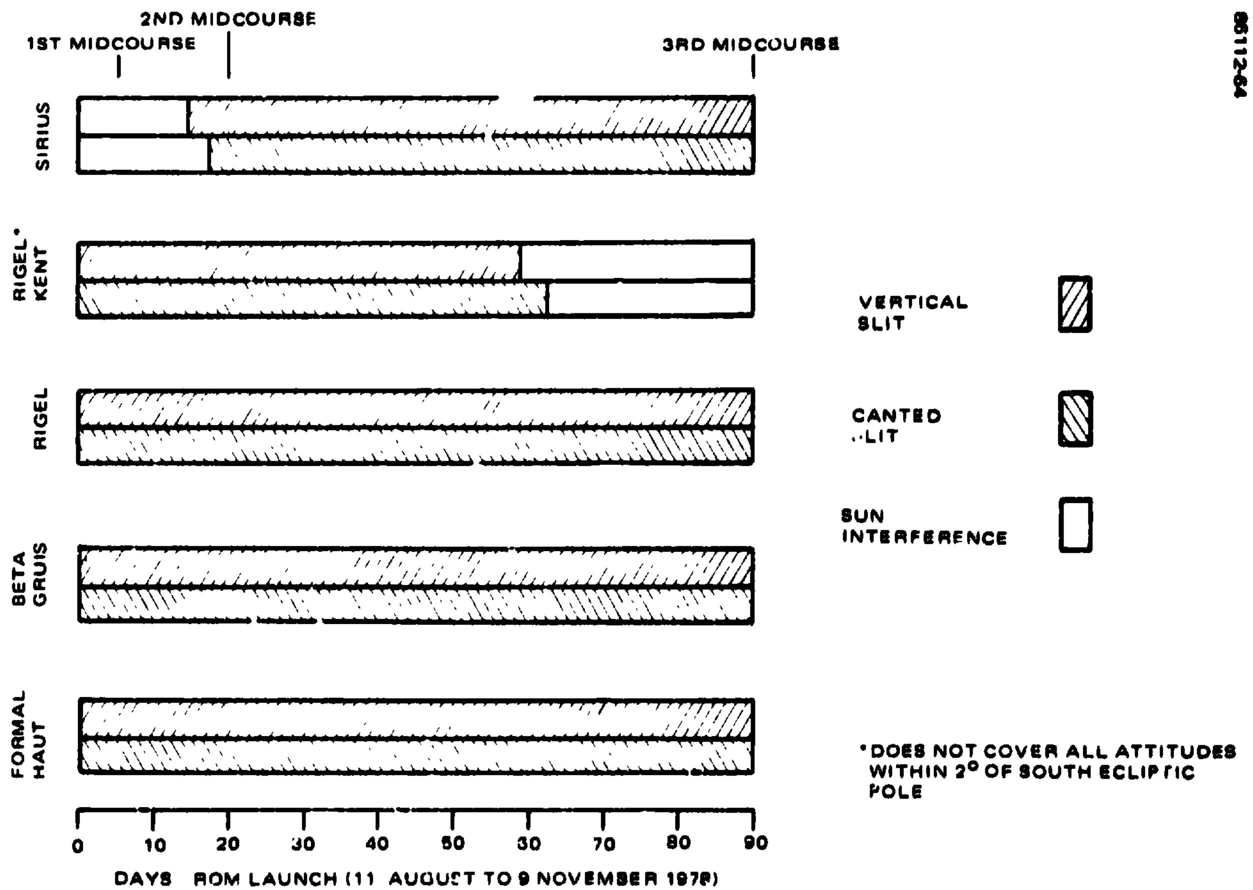

FIGURE 4.3.?.3-3. PROBE CRUISE STAR AVAILABILITY CHART – SOUTHERN HEMISPHERE

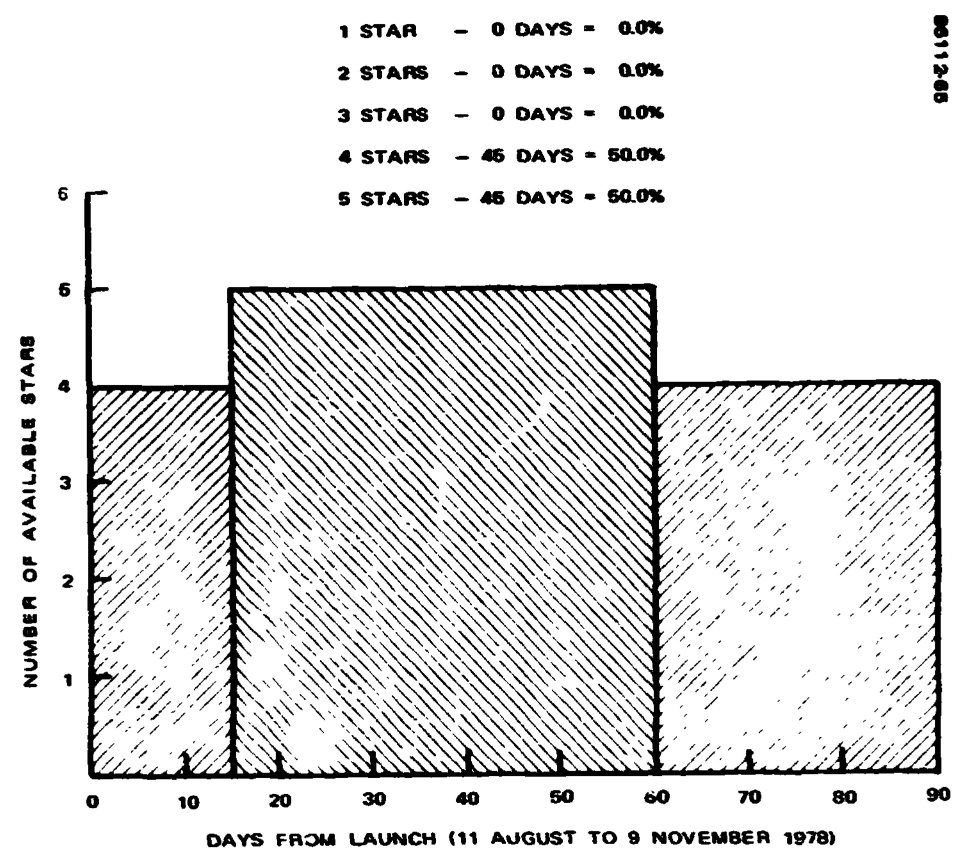

FIGURE 4.3.2.3-4 PROBE CRUISE – SOUTHERN HEMISPHERE (ECLIPTIC NORMAL ATTITUDE)

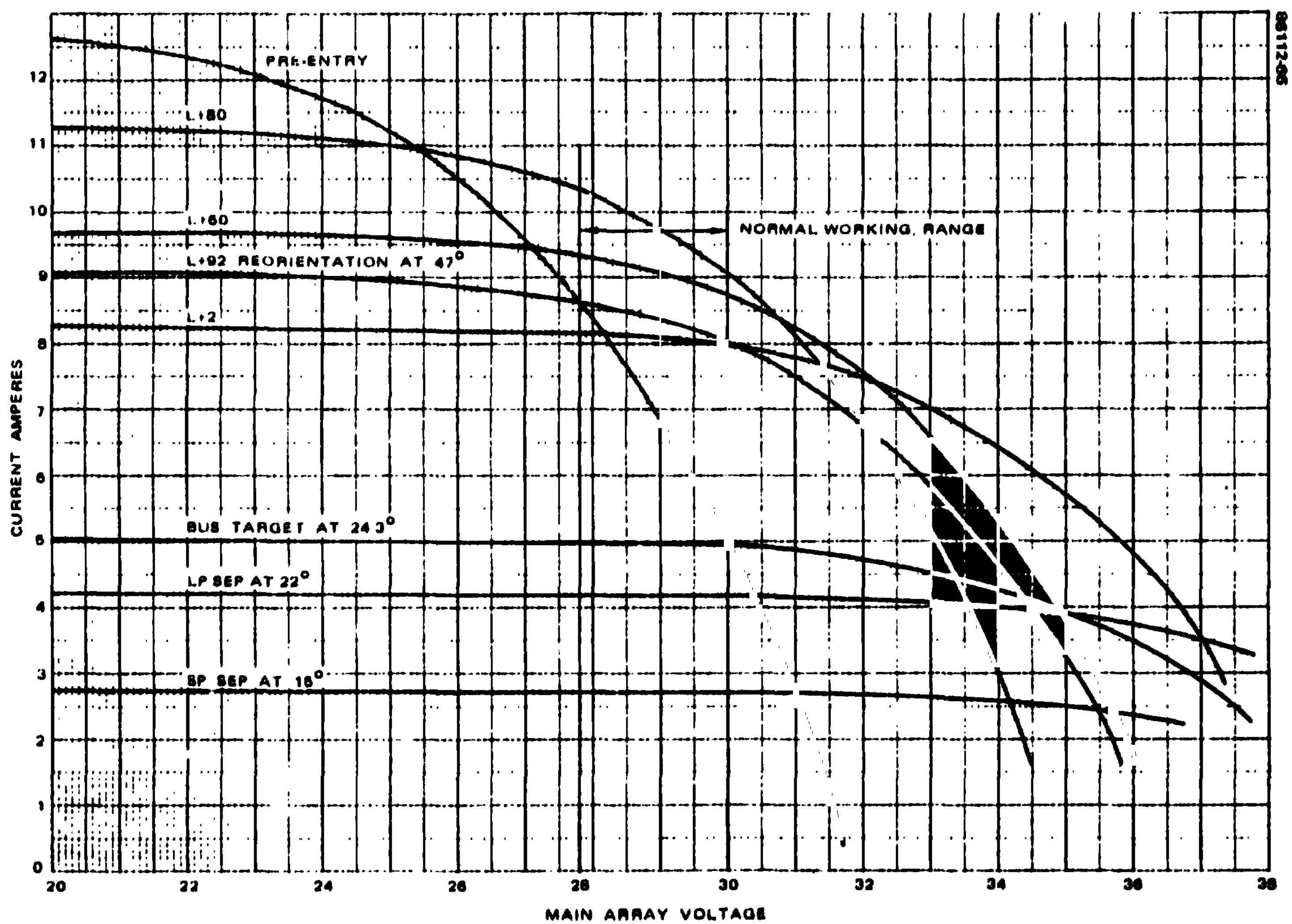

FIGURE 4.3.4.3-1. BUS MAIN SOLAR ARRAY (MINIMUM OUTPUT)

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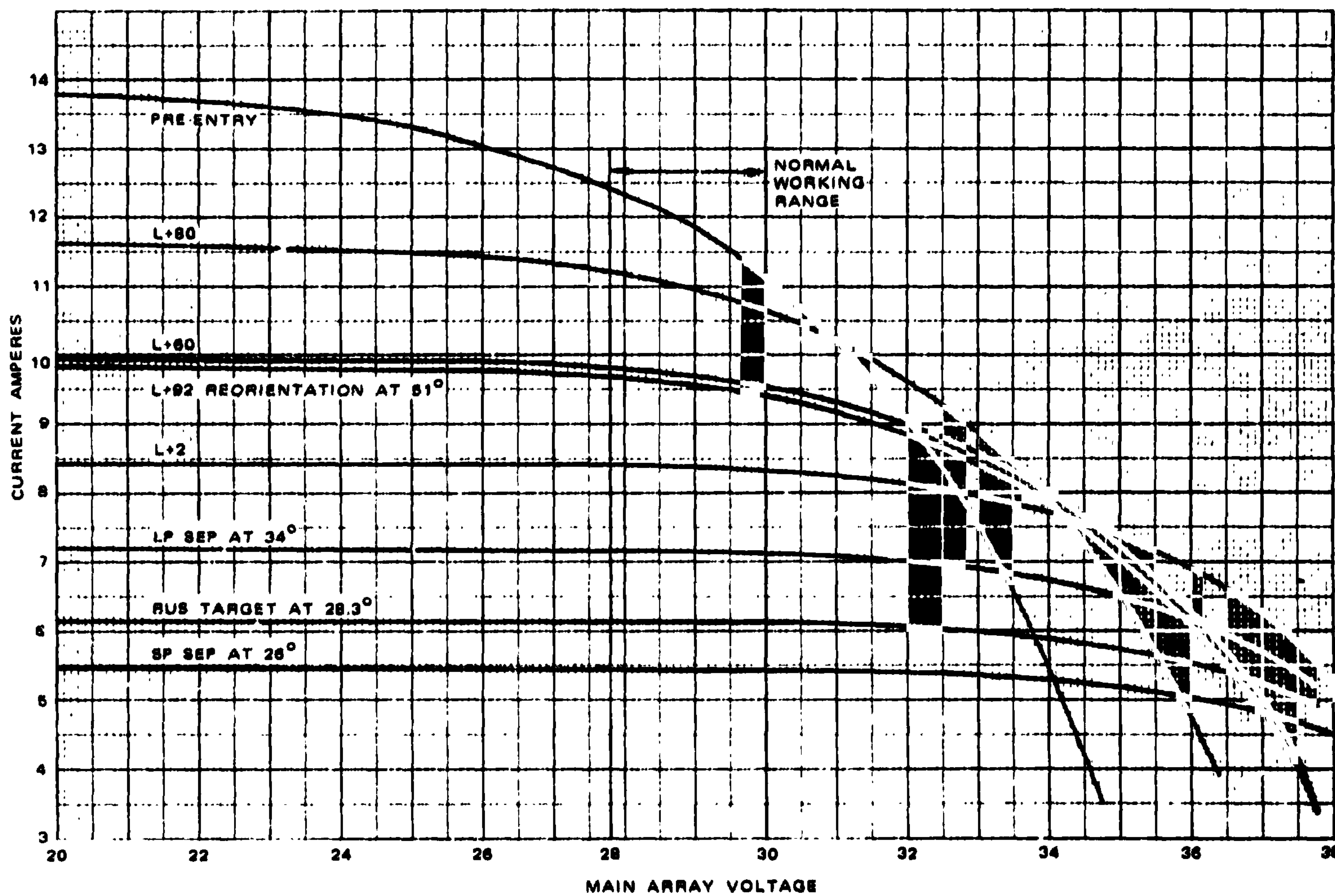

FIGURE 4.3.4.3-2. BUS MAIN SOLAR ARRAY (MAXIMUM OUTPUT)

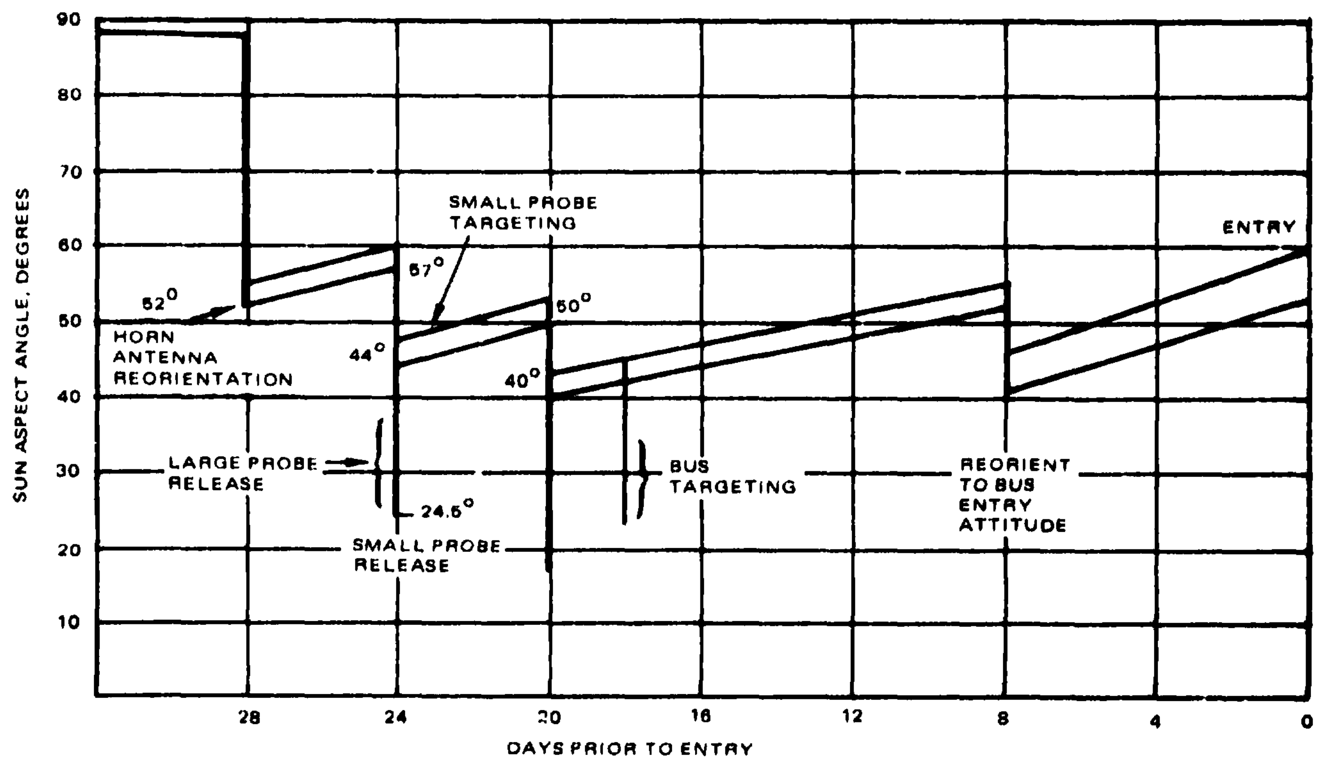

FIGURE 4.3.4.3-3. PROBE ENCOUNTER PHASE – MULTIPROBE SUN ANGLE HISTORY

5.0 PROBES DESCRIPTIONS

Functional and Operational descriptions of the Large Probe and Small Probe, as well as detailed performance in normal operating modes and backup modes, are presented ahead.

5.1 LARGE PROBE DESCRIPTION

The Large Probe is designed to enter and survive the Venus atmosphere and telemeter scientific information until impact with the Venus surface. It is attached to the Multiprobe Bus until nominally 24 days before entry into the Venus atmosphere at which time the probe is separated. From commanded separation until end of mission, the Large Probe is controlled by its internal coast timer, entry sequence programmer (ESP) and events sensed by an acceleration switch and a thermal switch. A description of the Large Probe system, operation, and mission is given in sections 5.1.1, 5.1.2, and 5.1.3, respectively.

5.1.1 Large Probe System Description. The Large Probe external configuration is shown in Figures 5.1.1-1, -2, and -3. Figure 5.1.1-1 depicts an external exploded view of the three separable parts including the pressure vessel module, deceleration module, and aft cover. All scientific instruments are contained within the pressure vessel module. Figure 5.1.1-2 indicates the dimensions of the assembled probe and separated pressure vessel module. The assembled probe is contained within a 56 inch diameter by 36.9 inch high envelope. The pressure vessel has an envelope diameter of 38.5 inches and height of 33.1 inches. Figure 5.1.1-3 presentr a cutaway view of the Large Probe and identifies the significant features.

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TABLE 5.1.1-1

LARGE PROBE SCIENTIFIC INSTRUMENT SUMMARY

Name of Instrument	Reference Designator	Function
Comparative Atmosphere Structure	ARC/LAS	Pressure, Temperature and Acceleration
Nephelometer	ARC/LN	Cloud Particulate Density Distribution
Cloud Particle Size Spectrometer	PMS/LCPS	Size, Independent of Optical Refraction
Infrared Radiometer	ARC/LIR	Differences in Upward and Downward Radiation
Neutral Mass Spectrometer	UTD/LNMS	Measurement of Non-corrosive gases; Identification of Active Constituents
Gas Chromatograph	ARC/LGC	H_2O, COS, Ar, CO, N_2, H_2, S, SO_2, HCl, O_2 and Kr relative abundances
Solar Flux Radiometer	Ariz/LSFR	Solar Energy Deposition as Function of Depth

The Large Probe contains seven scientific instruments to provide in situ measurement of the structure and composition of the Venus atmosphere and clouds. The function of each instrument is summarized in Table 5.1.1-1. Significant instrument accommodation features include three sampling inlets and four heated windows. A pressure vessel protects the instruments and the associated engineering support subsystems during descent to the planet's surface. The titanium

pressure shell maintains an internal atmosphere of nitrogen at a pressure from 8 to 30 psia. (Low thermal conductive Xenon is not used due to interference with the scientific instruments.) Instruments and engineering units are supported by two beryllium shelves which also provide a heat sink during descent. Internal components are thermally protected from the outside temperature by a Kapton multilayer blanket.

A deceleration module insulates the payload during atmospheric entry and provides deceleration to subsonic condition prior to parachute deployment at 67 KM (Kilometers) altitude. A 56 inch diameter, 45 degree, blunt cone aeroshell supports a carbon phenolic heatshield which ablates during entry to provide thermal protection. A fiberglass honeycomb aft cover surfaced with ESM and a teflon RF transparent flat section provides thermal protection of the aft hemisphere during entry. A 16.2 foot diameter (D_0) dacron conical ribbon parachute supports the payload during descent from 67 to 47 KM altitude. Spin vanes around the pressure vessel module provide positive spin (>1 RPM) during descent. Final descent to the surface is free fall with aerodynamic stability provided by a forward aerofairing, a conical skirt, and sectional drag plates.

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A configuration history of the Large Probe is depicted in Figure 2.1.1.2-1. As shown, a quick transition begins about 37 seconds after entry when the parachute deployment sequence is begun. Prior to this time the pressure vessel is encapsulated by the Deceleration Module. The parachute deployment sequence includes mortar fire, pilot chute deployment, and main chute deployment. The parachute pulls the pressure vessel module out of the Deceleration Module. Finally, about 18 minutes after entry the parachute is jettisoned and the pressure vessel begins free fall descent to the surface.

Prior to probe separation, power is provided from the Bus spacecraft solar panel. Power is supplied after probe separation (E-24 days) by a 40 amp-hour silver zinc battery which has a useful capacity (to 80% DOD) at probe separation of 22.38 amp hours. The bus voltage is expected to be maintained within 26.2 and 28.2 vdc (25.2 and 30.8 vdc spec) during entry and descent operation. Initial connection of internal battery power is achieved by command from the Bus to a redundant pair of magnetic latching relays. On/Off control of remaining spacecraft loads is provided by additional relays. Overload protection is provided by parallel fuses.

A power load profile is given in Figure 5.1.1-4. The total load including all engineering units and scientific instruments is illustrated from Bus separation until impact.

Prior to probe separation, downlink communications is by hardwire telemetry of the probe data subcarrier to the Bus. Downlink communications during probe entry and descent is provided by four solid state power amplifiers each rated at 10 watts RF and a crossed dipole antenna. A minimum EIRP of 35 dBm/steradian is provided over communication angles (from the -Z axis) of 40 to 60 degrees. A transponder accommodates two way Doppler tracking and provides a coherent frequency reference for the downlink.

Two data rates (128 or 256 bps) are transmitted in a convolutionally encoded PCM/PSK/PM format. Forty-nine unique data channels (23 for science; 26 for housekeeping) are formatted in two major frame formats (Descent and Blackout) each containing 16 minor frames. Each minor frame consists of sixty-four 8 bit words. There is a unique 64 word subcommutated format associated with each major frame format. Seven data channels (2 of which are also transmitted in the probe telemetry stream) are separately hardwired to the Bus telemetry stream, including one serial digital channel which requires three wires (data, read envelope, read clock). A 3072 bit solid state memory is used to store data during entry blackout.

Prior to probe separation the internal sequence is inhibited by a hardwire across the IFD. During this time, control of the probe is through 5 hardwire lines from the Bus (three of which, data, envelope and clock, accommodate a quantitative command to set the coast timeout duration) and one command output module which decodes and routes 43 command functions from the Bus.

After probe separation, the probe is controlled by coast timer, ESP, and acceleration switch and has no provision for reception of ground commands. Fifty-three internal command functions are utilized; 128 executions are implemented in eight sequences of 16 commands each. The sequence is permanently programmed into the ESP PROMs prior to unit assembly. The sequences cannot be changed by command or other means subsequent to fabrication of the C/DU. The ESP is initiated by timeout of the coast timer (or by acceleration switch as a back-up). Actuation and reset of the acceleration switch and actuation of the thermal switch initiates particular sequences. Entry and descent command timing is controlled by an internal timer.

The probe is electrically separated from the Bus by command from the Bus of a pyrotechnic in-flight disconnect (IFD). Mechanical separation

of the probe from the Bus is achieved by simultaneous command from the Bus of three pyrotechnic separation devices. Seven pyrotechnic functions configure the probe during entry and descent; they cannot be exercised while on the Bus unless the probe is on internal battery power and the IFD is separated. The firing commands are originated by the C/DU. These functions include pressurized gas release, pilot chute mortar fire, aft cover release, pressure vessel/aeroshell electrical and mechanical separation, LNMS Breakoff cap separation, and parachute jettison.

After probe separation, the probe is controlled by an internal sequencer and has no provision for reception of ground commands. Forty-six internal command functions are utilized; 128 executions are implemented in eight sequences of 16 commands each. The sequencer is initiated by timeout of the coast timer. Additional external stimuli which initiate particular sequences include actuation and reset of the deceleration switch and actuation of the temperature switch. Entry and descent command timing is controlled by an internal timer. Prior to probe separation the internal sequence is inhibited by a hardwire line across the IFD. During this time control of the probes is through five hardwire lines from the Bus (three of which accommodate a quantitative command to set the coast timeout duration) and one command output module which decodes and routes 43 command functions from the Bus.

The location of units on the forward and aft shelves are shown in Figures 5.1.1-5 through 5.1.1-8. The figures depict forward and aft views of each shelf. The forward looking view of the aft side of the aft shelf demonstrates the colocation of the communications subsystem in this area. The mid bay, including the forward side of the aft shelf and aft side of the forward shelf, is shown to consist primarily of scientific instrumentation. The remaining forward side of the forward shelf is dominated by the probe battery.

5.1.2 Large Probe Operation. There is no external control of the probe after it separates from the Bus; the operational characteristics prior to separation are emphasized in this section.

5.1.2.1 Capabilities and Limitations. Once the Large Probe is separated from the Bus there is no external command capability. In addition, there is no telemetry from the Large Probe throughout the 24 day coast period. Probe telemetry is transmitted only during the final 1-1/2 hours of the probe mission (pre-entry, entry, and descent). The expected spacecraft signature during this 1-1/2 hour period is included in the Large Probe entry and descent sequence, Table 5.1.3-1.

Prior to separation, operation of the Large Probe consists of periodic turn-on to checkout instrument and subsystem operation. Checkout limitations are described in section 5.1.2.1.2. The capabilities and limitations of the activities required for separation of the probe from the bus are discussed below and in section 4.1.3.2.

5.1.2.1.1 Interplanetary Cruise. Except for brief periods of probe checkout discussed below in 5.1.2.1.2 the probe operations capability during interplanetary cruise is limited to application of power to shelf heaters and monitoring the shelf and battery temperatures. One heater on each shelf (the forward shelf heater contains two separate elements) is provided power from the Bus on a separate line from checkout power. These heaters are powered on and off by command of a relay on the Bus. A separate telemetry channel indicates the temperature of each shelf. This telemetry requires no external power; it is conditioned by the Bus spacecraft and is available continuously during the cruise phase. The locations of the shelf heaters and temperature sensors are shown in the unit installation drawings, Figures 5.1.1-5 through 5.1.1-8. Two temperature sensors are indicated on each shelf (SLFW1T and SLFW2T for the Forward Shelf; SLAF1T and SLAF2T for the AFT Shelf). One

sensor is on each shelf (SLAF1T or SLFW1T) is wired to a Bus DIM; the other sensor on each shelf is wired to the probe C/DU. The battery temperature sensor (PLBATT) is mounted internally in the battery pack and is wired to a BUS DIM.

5.1.2.1.2 Probe Checkout. This section discusses the operational capabilities and limitations of probe checkout while the probe is attached to the Bus. Instrument checkout data will also be telemetered by the probe just before entry but no external operational control will be possible at that time.

5.1.2.1.2.1 Thermal Constraints. Probe checkout cannot be implemented early in the cruise phase because the probe temperature is below the minimum operating limit with the probe shelf heaters on continuously. Temperatures increase as the Multiprobe gets closer to the sun. At about Launch +60 days the minimum operating temperature (-4°F shelf temperature, telemetry channels SLAF1T and SLFW1T) is exceeded and probe checkout can be implemented. Any one or more scientific instruments on the Large Probe may be operated indefinitely during checkout of that probe as long as [SLFW1T AND SLFW2T AND PLBATT are all ≤ +85°F] AND [SLAF1T AND SLAF2T are both ≤ +122°F]. Once any limit is reached the equipment should be turned OFF, and checkout of the Large Probe should not be resumed until the telemetered temperature that indicated the limit level has decreased by ≥ Δ 5°F.

5.1.2.1.2.2 Commands/Telemetry. Forty-six commands are available for use during probe checkout. These commands are described in PC-455, Reference Paragraph 1.5.1. Of these, 43 are routed through the Large Probe COM (No.7) and the rest through Bus COM's. The commands can be generated in real time from the ground or can be stored in the Bus command memory for subsequent execution. Diagrams of the operational flow of each command, the interactions of commands, the required power signals, and the telemetry verification of commands are given in section 5.1.2.3.

Fifty-four unique telemetry channels are available to monitor probe status during checkout. Five are available through Bus DIM's only, 47 through the probe data stream only, and 2 through both paths. These signals are described in PC-454, Reference Paragraph 1.5.2 according to whether they are transmitted in the probe data stream that modulates the probe subcarrier or hardwired to the Bus DIM's. Further identification is made in the command and telemetry flow diagrams (Figure 5.1.2.2-1). Real-time telemetry of the probe data stream can be transmitted at 128 or 256 bps in either one of two data formats. Telemetry of the data channels which are wired directly into a Bus format rather than the probe C/DU telemetry stream can be transmitted at any Bus data rate from 8 to 2048 bps as long as the Bus data link margin is adequate. There is no data storage capability on the Bus.

5.1.2.1.2.3 Communications. Telemetry during probe checkout utilizes the Bus downlink only. The Bus carrier is modulated with the probe subcarrier and a Bus subcarrier consisting of the selected Bus format. The output power is either 10 or 20 watts. A direct probe signal is not expected to be detectable on the ground; therefore, probe communications subsystem operating characteristics cannot be determined. The probe communications subsystem may be turned on during checkout and the associated current dissipation used to indicate subsystem status.

5.1.2.1.2.4 Power. Probe checkout power is provided from the Bus solar panel and, if required, from the Bus battery. The probe battery is not connected until final preparation for separation. Near Earth, low solar intensity and corresponding reduced solar panel output limits probe checkout capability. However, checkout at this time is precluded by the thermal constraint discussed in Paragraph 5.2.2.1.2.1. The thermal constraint passed at about L+60 days. At this time 35 watts of solar panel power is available for probe checkout, assuming the full specified 30 watts of Bus science power is simultaneously drawn. If

the Bus scientific instruments are not powered during probe checkout, a total of 65 watts of power is available. In addition, energy may be extracted from the Bus battery to support a higher checkout power for a limited period. With 35 watts, only single instruments can be powered indefinitely for checkout. However, regardless of power availability, simultaneous checkout of all Large Probe instruments is thermally limited as discussed in section 5.1.2.1.2.1. Power availability assumes there will be no power supplied to any Small Probe at the time of Large Probe checkout. There is only one data line available for probe checkout data and external multiplexing from several probes is not possible. There is, therefore, no need to power more than one probe at a time.

The expected load current for each probe unit is given in Table 5.1.2.1.2.4-1. The load current for each scientific instrument is given in Table 5.1.2.3.1.3-1.

5.1.2.2 Subsystem Operability. Figure 5.1.2.2-1 illustrates the flow of externally generated commands within the Large Probe. Internal command generation after probe separation from the Bus is not considered. The flow of external probe commands through the Bus is not shown in detail, i.e., from reception by the Bus receiver through transmission across the IFD and, when appropriate, to the probe COM. Figure 5.1.2.2-1 traces the command signals from the hardwire input or probe COM to the point of execution. All other signals, command and power, are indicated which are required before the command path is closed. Telemetry points are indicated which verify activity along each command path. Additional telemetry channels are indicated which do not refer to the indicated commands and are not directly related to probe checkout. These channels are included because they are available during checkout if desired.

Two types of telemetry channels include those available directly across the In-Flight Disconnect (IFD) bypassing the C/DU, and those

available through the hardwired probe telemetry stream from the C/DU. The two types are identified in the figure according to the two indicated paths: one directly to a Bus Data Input Module (DIM) across the IFD and the other to the C/DU in one or both data formats.

5.1.2.2.1 Command/Data Subsystem. The twelve (12) commands possible from the Bus to the command/data subsystem are traced in Figure 5.1.2.2-1. As indicated, three commands come directly from the IFD and nine from the probe COM. The two commands to the coast timer are redundantly routed through each path. Seven associated telemetry channels include one transmitted directly and six transmitted within the probe telemetry stream, assuming use of the probe descent data format. Memory readout (MRO) is also indicated. The coast timer commands are significant because they are not for probe checkout but are required to configure the probe prior to separation.

5.1.2.2.2 Power Subsystem. The fourteen commands from the Bus that control the probe power subsystem are traced in Figure 5.1.2.2-1. As indicated, ten commands come from the COM. The remaining four commands control relays or relay drivers on the Bus. Fifteen associated telemetry points include four transmitted directly and eleven transmitted within the probe telemetry stream using either probe data format. The internal power ON command is significant because it is not used for probe checkout but is required to enable probe internal power prior to separation. The internal power switch interface is unique in that the relay driver is contained in the Bus PIU and the driver output lines to the relay cross the interface.

5.1.2.2.3 Communications Subsystem. The probe communications subsystem operates in one mode only. Therefore, no commands are required by the communications subsystem. There are four telemetry channels from the communications subsystem available in the probe telemetry stream to the Bus. These are shown in Figure 5.1.2.2-1. The communications subsystem can be turned on

during checkout by command of a power relay within the PIU.

5.1.2.2.4 Other Subsystems. Additional operational features of the Large Probe include external power and telemetry lines to and from the probe shelf heaters, telemetry from an internal pressure gauge, LIR window temperature telemetry, and temperature telemetry from the deceleration modules. The shelf heaters are commanded ON and OFF via a switch within the Bus as appropriate during the cruise mission. The ON/OFF commands are routed through redundant Bus COM's to the Bus PIU. The shelf heater command, power, and telemetry lines are depicted in Figure 5.1.2.2-1. Also shown is LIR window temperature which is telemetered by the C/DU to provide calibration information. Internal pressure is telemetered by the C/DU to indicate integrity of the pressure vessel seals. This telemetry channel is depicted in Figure 5.1.2.2-1. Also included in this diagram are four deceleration module temperature channels telemetered by the C/DU to provide an indication of heatshield performance.

5.1.2.3 Probe/Probe Instruments Interface. The electrical interface consisting of commands, telemetry, power, and timing signals, between the Large Probe and its seven scientific instruments, is presented in section 5.1.2.3.1. The mechanical interface between the probe and probe instruments with respect to individual instrument orientation and field of view is presented in section 5.1.2.3.2.

5.1.2.3.1 Electrical Interface. The electrical interface between the Large Probe and the probe scientific instruments consists of 21 command lines, 23 telemetry lines, a power distribution bus, and timing signals.

5.1.2.3.1.1 Commands/Telemetry/Timing Signals. Table 5.1.2.3.1.1-1 breaks down the 21 command and 23 telemetry channels available for the scientific instruments from the probe C/DU. The telemetry channels are further identified as either analog, serial digital or bilevel. Also included in the

table is identification of the timing signals provided to each instrument. Available timing signals include Read Envelope, Read Clock, Major Frame Rate, Minor Frame Rate, and 2048 Hz Clock.

5.1.2.3.1.2 Data Formats. The data from the individual scientific instruments are formatted into two minor frame formats, each of which includes 4 subcommutated words (see PC-454, Reference: Paragraph 1.5.2, for formats definitions). The descent format is transmitted before entry to provide instrument checkout data and after entry during traversal of the upper atmosphere to provide measurement data from each of the seven instruments. The analog and bilevel channels indicated in Table 5.1.2.3.1.1-1 are subcommutated with a sampling rate of one word every 32 seconds at the Large Probe data rate of 256 bps. Serial digital data are telemetered within the minor frame at a rate of one sample (8 bits) every 2 seconds. The blackout format is utilized at 128 bps during high speed entry deceleration. The blackout format includes atmospheric structure data, Nephelometer calibration data, and telemetry of deceleration module temperature. Each minor frame word is transmitted every 4 seconds, each subcommutated word is transmitted every 64 seconds. Six frames of data (24 seconds) are stored during blackout and subsequently transmitted in one word of the descent format. One complete data storage readout requires 12.80 minutes. The data playback automatically repeats until end of mission.

5.1.2.3.1.3 Power. Power to the scientific instruments is provided from the probe battery via the power interface unit. Each instrument is separately fused. In addition, a parallel fuse is wired through a second power relay to provide a "one-time" reset capability in the event of a primary fuse trip. The expected load current of each scientific instrument is indicated in Table 5.1.2.3.1.3-1.

5.1.2.3.2 Mechanical Interface. The location and orientation of each instrument on the probe and

the clear field of view provided for each instrument are indicated in Figure 5.1.2.3.2-1.

5.1.3 Large Probe Entry/Descent Sequence. The nominal sequence and failure modes are described ahead.

5.1.3.1 Nominal Sequence. After the Large Probe is switched via the Bus command link to internal power, the coast timeout duration is set and the probe coast timer is initiated. Separation from the Bus follows shortly at nominally E-24 days. After separation the Large Probe is controlled by an internal coast timer, event sequence programmer (ESP), and specific events sensed by an acceleration switch and a thermal switch. There is no external command capability after electrical separation.

The coast timer provides a pre-timeout signal at Entry - 150.5±2 minutes to turn on the receiver and battery heater. At E-22±2 minutes, the coast timer reaches the timeout duration which causes turn on of the probe command/data unit and turn off of the battery heater. The stored command sequence listed in Table 5.1.3-1 is initiated and probe RF transmission (carrier only) begins. The two minute uncertainty associated with events prior to entry into the Venusian atmosphere is largely eliminated by reinitializing event timing upon actuation of the acceleration switch, which signifies the start of aerodynamic braking.

Between probe separation from the Bus and initiation of RF transmission, there is no capability for determination of probe status. In addition, during the next five minutes, the data subcarrier is suppressed to enhance ground acquisition of the unmodulated downlink carrier. Telemetry of spacecraft unit data and scientific instrument data is initiated by the sequencer after the five minute period. Bilevel status telemetry; telemetry of temperatures, voltages, and currents; and RF characteristics indicate the status of the probe. Predicted frequencies are listed in Table 5.1.3.1-1.

The probe mission phases after coast timer timeout include: 1) calibration of the scientific instruments prior to entry, 2) blackout during entry when all data are stored and the ground loses the probe RF signal, 3) upper altitude parachute descent, and 4) lower atmosphere free fall descent. Impact occurs at approximately E+55 minutes.

The nominal Large Probe entry location is shown in Figure 2.1.1.3-1. Entry trajectory parameters for this entry location are shown in Figure 5.1.3-1. The nominal trajectory is based on the entry conditions and ballistic coefficient defined in the next paragraph. The nominal descent trajectory parameters are shown in Figures 5.1.3-2 and 5.1.3-3, based on the parachute deployment and jettison parameters and the aerodynamic properties defined in the next paragraph.

Table 5.1.3-1 indicates the time from entry of each command and the altitude and other trajectory parameters at significant milestones. The entry trajectory parameters and timing are based on a nominal flight path angle of -33.8 degrees, velocity of 11,600 m/sec at 200 KM altitude, and an entry ballistic coefficient of 38.90 lbs/ft². The descent trajectory parameters are based on nominal parachute deployment at E+37.89 seconds, at an altitude of 67.02 KM; and parachute jettison at E+1064.07 seconds, at an altitude of 46.94 KM. The timing is based on an estimated maximum probe weight at entry of 690.13 pounds, weight on the chute of 450.68 pounds, and final descent weight of 433.12 pounds. The assumed aerodynamic properties include a parachute C_DA of 108.5 ft² and a pressure vessel C_DA of 4.4 ft². C_DA is called the Drag Area or Drag Product, where A=Parachute or pressure vessel reference area and C_D=the Drag Coefficient.)

The sequence indicates that the window heaters will be on until end of mission. The final selection depends on final determination of probe battery margin.

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Table 5.1.3-1 indicates when particular telemetry channels will change value to verify that a particular sequence event has occurred. In addition, characteristics of the received RF signal will provide indication of turn on of the RF equipment, initiation of subcarrier modulation, entry blackout, and impact. Post real time analysis of the received RF waveforms and signal strength will assist in determination of atmospheric properties including turbulence and winds.

Many of the sequence command executions are not required for nominal operation but provide backup. Backup commands are given a reference letter corresponding to each specific failure mode. The failure modes associated with each reference letter are described in Section 5.1.3.2 ahead. The "J" reference letter identifies command executions which are not associated with a particular failure mode but which provide backup to random failure of a command execution.

5.1.3.2 Failure Modes. Although the Large Probe is basically a single string non-redundant configuration, various backup capabilities of particular components have been utilized. In particular, 1) the acceleration switch provides a backup to failure of the coast timer (Backup B), 2) commands reestablish the configuration if an inadvertent relay transition has been caused by the high-g entry loads (Backup C), 3) a secondary scientific instrument power bus reconnects instruments that have experienced a transient short during entry (Backup D), 4) anomalies during parachute jettison are removed by reestablishing the desired operating configuration (Backup E), 5) timed commands are provided as backup for acceleration switch failure (Backup I), and the thermal switch provides a backup to degraded parachute performance to assure jettison of the parachute above 46 KM altitude (Backup K).

These backup modes are summarized in Table 5.1.3-2. The change in spacecraft signature is indicated, and the implications on ground

operations are summarized. The recognition of these peculiar signatures will enable identification of the failure and what backup has occurred.

Several additional backup modes do not significantly change the spacecraft signature and in no way alter ground operations. These include: 1) command backup of the C/DU initial conditions circuitry (Backup F), 2) dual pyrotechnic arm and fire commands to backup random failure of a single command (Backup G), and 3) acceleration switch backup of timed commands to turn off certain scientific instruments prior to entry (Backup H). For completeness, these backup modes are included in Tables 5.1.3-1 and 5.1.3-2, along with "backup J" which, as described above, provides backup to a random failure to execute a particular command. The designator "Backup A" is not used.

TABLE 5.1.2.1.2.4-1

CHECKOUT LOAD CURRENT FOR LARGE PROBE UNITS

POWER RELAY	UNIT NAME	AVERAGE LOAD CURRENT (@29 VDC) (AMPERES)
Internal Power	Coast Timer	0.001
Receiver	Receiver	0.073
Battery Heater	Not Accessible from Bus	N/A
RF	Exciter Power Amplifier Output Amplifiers	0.131 1.555 4.666
C/DU	Command/Data Unit PCU Pressure Gauge PIU	0.271 0.000 0.015 0.026
Science Primary	Science Instruments (Initial current spike with no residual load current -- Individual instrument load currents given in Table 5.1.2.3.1.3-1)	(1.0 Amp. peak when using pre-charge.)
Science Backup	Same as Science Primary	
Window Heater	LSFR Window Heater LN Window Heater LCPS Window Heater	1.302 1.725 1.087
LIR Window Heater I	LIR Window Heater	0.883
LIR Window Heater II	LIR Window Heater	2.343

TABLE 5.1.2.3.1.1-1

SCIENCE (C/DU) SIGNAL INTERFACE LINES

INSTRUMENT	COMMANDS FROM C/DU	TELEMETRY CHANNELS TO C/DU: ANALOG	SERIAL DIGITAL	BILEVEL	TIMING SIGNALS: READ ENVELOPE	READ CLOCK	MAJOR FRAME RATE	MINOR FRAME RATE	2048 Hz CLOCK
Comparative Atmosphere Structure	4	1	1	1	1	1	1	1	1
Nephelometer	1	4	1	1	1	1	0	1	0
Cloud Particle Size Spectrometer	2	0	1	1	1	1	1	1	0
Infrared Radiometer	2	0	1	1	1	1	0	1	1
Neutral Mass Spectrometer	5	1	1	1	1	1	1	1	1
Gas Chromatograph	5	1	1	1	1	1	0	0	1
Solar Flux Radiometer	2	2	1	1	1	1	1	1	0

TABLE 5.1.2.3.1.3-1

LARGE PROBE SCIENTIFIC INSTRUMENT LOAD CURRENT (AT 28 VDC)

INSTRUMENT	AVERAGE CURRENT DISSIPATION AMPS	PEAK CURRENT DISSIPATION AMPS
Comparative Atmospheric Structure	0.16	0.31
Nephelometer	0.08	0.08
Cloud Particle Size	0.66	0.66
Infrared Radiometer	0.20	0.24
Neutral Mass Spectrometer	0.39	0.50
Gas Chromatograph	0.61 to 1.6	0.93 to 2.0
Solar Flux Radiometer	0.13	0.13

TABLE 5.1.3-1

LARGE PROBE ENTRY/DESCENT SEQUENCE

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Pre-Entry RF Acquisition/ Coast Timer Timeout	0.000	48	1) Reset Descent Timer to Zero	-1320.000			-		E-22 min., Automatic C/DU Power Relay ON, Battery heater OFF, Two C/DU power relays have status telemetry on channels 55(2) and 55(3). C/DU performance indicated by oscillator temperature Channel 0; 2 min timing uncertainty; E=0 defined at 200 km altitude; 5 min. allowed for ground lockup of communications link.
	0.000	59	2) Receiver ON (A)	-1319.875			*		
	0.000	43	3) Subcarrier OFF	-1319.750			-		
	0.000	55	4) RF Power Relay ON (Also "Arm PCU")	-1319.625	63(3)	PLRFRS	ON/OFF	0 to 1	
	0.000	53	5) Science Pwr Primary Relay ON (Also "Fire Gas Bottle")	-1319.500	63(4)	PLSP1S	ON/OFF	0 to 1	
	0.000	25	6) LGC Power ON	-1319.375	59(5)	ELGCS	ON/OFF	0 to 1	
	3.750	27	7) LGC Start Warm Up (Also "Disarm PCU")	-1316.250			-		
	5.750	28	8) LGC TIV Actuate	-1314.250			-		
Pre-Entry Science Warmup and Calibration	300.000	44	9) Data Rate 256 bps Select	-1020.000	46(7)		ID	0 to 1	E-17 min., telemetry initiates here. Each minor frame word repeated every 2 seconds. Each subcommutated word repeated every 32 seconds.
	0.000	50	10) Descent Format Select (F)	-1019.875			**		
	0.000	60	11) LAS Power ON	-1019.750	59(0)	ELASS	ON/OFF	0 to 1	
	0.000	06	12) LN Power ON	-1019.625	59(1)	ELNS	ON/OFF	0 to 1	
	0.000	10	13) LCPS Power ON	-1019.500	59(2)	ELCPSS	ON/OFF	0 to 1	
	0.000	18	14) LNMS Power ON	-1019.375	59(4)	ELNMSS	ON/OFF	0 to 1	
	0.000	30	15) LSFR Power ON	-1019.250	59(6)	ELSFRS	ON/OFF	0 to 1	
	0.000	14	16) LIR Power ON	-1019.125	59(3)	ELIRS	ON/OFF	0 to 1	
					32	PLBUSI	Bus Current***	-	First reported current = 10.1amps

*Pretimeout signal at E-150.5 min. automatically turns on receiver and battery heater. Subsequent (after E-17 min.) bilevel telemetry, bit 63(7), verifies that receiver is ON but not whether initiation is by pretimeout signal or backup. Initiation by pretimeout signal is verified if uplink lock is established (indicated by the downlink transmission being coherent with the uplink) at the time RF is turned on. Otherwise the backup signal will turn on the receiver and a downlink frequency shift will be observed after the uplink is locked up. Receiver performance is verified by telemetry of VCO temperature, AGC voltage, and static phase error, Channels 5, 34 and 35 respectively.

**Backup commands cannot be verified since probe is already in the related state. Verification telemetry is therefore not included in this table.

***Any change in battery load will not only result in a change in telemetered bus current, Channel 32, but also will result in a small change in battery voltage, Channel 33, and a change in shelf temperature, Channels 2 and 3.

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Pre-Entry Science Warmup and Calibration (Continued)	0.000	44	1) Data Rate 256 bps Select (J)	-1019.000			**		
	370.625	19	2) LNMS Pre-Entry	-959.375			-		E-16 min.
	720.000	01	3) LAS Calibrate	-600.000			-		E-10 min.
	1020.000	16	4) LIR Power OFF	-300.000	59(3)	ELIRS	ON/OFF	1 to 0	E-5 min.
	0.000	11	5) LCPS Power OFF	-299.875	59(2)	ELCPS3	ON/OFF	1 to 0	
	0.000	31	6) LSFR Power OFF	-299.750	59(6) 32	ELSFRS	ON/OFF Bus Current	1 to 0 -? ?	***
	0.000	45	7) Data Rate 128 bps Select	-299.625	46(7)	PLBUSI	ID	1 to	
	0.000	46	8) Blackout Format Select	-299.500	46(5,6)		ID	00 to 01	
	0.000	02	9) LAS Blackout	-299.375			-		
	0.000	47	10) Stored Data Initiate (F)	-299.250			**		Stored data are written over until T+5.515 sec. Stored data mode established by initial conditions and verified if telemetry status bit 46(0)=1.
	0.000	53	11) Sci Pwr Prim'y Relay ON (J)	-299.125			**		
	0.000	00	12) LAS Power ON (J)	-299.000			**		
	0.000	46	13) Blackout Format Select (J)	-298.875			**		
	0.000	02	14) LAS Blackout (J)	-298.750			**		
	1200.000	07	15) Unused	-120.000			-		
	1500.000	55	16) RF Power Relay ON (I) (Also "Fire Gas Bottle")	+180.000			**		•Backup Initiation of next sequence. •Gas Bottle already fired at E-1319.5 sec. Also PCU is now disarmed.

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Blackout/ G-Switch	0.000	53	1) Sci Pwr Prim'y Relay ON (B)	15.930			**		5.5g's(inc.), 97.9 km. Automatic C/DU Power ON and Battery; Heater OFF. Late Switch actuation at 7.0g corresponds to E+16 10 sec. Switch status bit, 46(1)=1, not likely to be telemetered before switch reset. Actuation verified by nominal operation after entry. Enter blackout at E+13.20 sec., 115.4 km., 0.05g. Loss of RF signal on ground.
	0.000	26	2) LGC Power OFF (1)	16.055	59 (1) 32	ELGCS PLBUS1	ON/OFF Bus Current	1 to 0 -1.2A	
	0.000	16	3) LIR Power OFF (B)	16.180			**		
	0.000	11	4) LCPS Power OFF (B)	16.305			**		
	0.000	07	5) Unused	16.430			-		
	0.000	31	6) LSFR Power OFF (B)	16.555			**		
	0.000	45	7) Data Rate 128 bps Select (B)	16.680			**		
	0.000	46	8) Blackout Format Select (B)	16.805			**		
	0.000	00	9) LAS Power ON (B)	16.930			**		
	0.000	02	10) LAS BLACKOUT (B)	17.055			**		
	0.000	48	11) Reset Descent Timer to Zero	17.180			-		
	0.000	59	12) Receiver ON (B)	17.305			**		
	0.000	55	13) RF Power Relay OF (B) (Also "Fire Gas Bottle")	17.430			**		Gas Bottle already fired at E-1319.5 sec. Also RCU is now disarmed.
	5.000	52	14) Enable Acceleration Sw Reset	22.180			-		Peak Acceleration at E+19.48 sec., 77.7 km, 321g. Exit Blackout at E+21.30 sec., 73.0 km, 3km/sec - resumption of downlink reception on ground. Uplink and downlink relock required.
	6.000	52	15) Enable Accel Sw. Reset (J)	23.180			**		
	20.000	49	16) Stored Data OFF (I)	37.180			**		Backup initiation of next sequence.

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Post Blackout/ G Switch	0.000	48	1) Reset Descent Timer to Zero	29.390			-		5.5g's (dec.), 68.4 km, ±5% Switch reset [illegible] certainty corres[illegible] [illegible] .4s to ±0.15 sec. Switch state verification at status bit 46([illegible])=0, however if switch actuation does not take place, reset is not acknowledged. Failure to execute timer reset command will result in early parachute deployment and severe degradation of mission.
	0.000	49	2) Stored Data OFF	29.515					
					46(0)		1E	[illegible] to 0	
	0.000	44	3) Data Rate 256 bps Select	29.640					
					46(7)		1I	0 to 1	
	0.000	50	4) Descent Format Select	29.87[illegible]					
					46(5,6)		ID	01 to 00	
	0.000	03	5) LAS Descent	29.890					
	0.000	53	6) Set Pwr Prim'y Relay ON (C)	30.015			**		
	0.000	06	7) LN Power ON	30.140	59(1)	RLN[illegible]	ON/OFF	0 to 1	
	0.000	55	8) RF Power Relay ON (C) (Also "Fire Gas Bottle")	30.275			**		Gas Bottle already fired at E-1319.5 sec. Also, PCU is now disarmed.
	0.000	25	9) LGC Power ON	30.390	59(5)	RLGCS	ON/OFF	0 to 1	
	0.000	10	10) LCPS Power ON	30.515	59(2)	RLCPSS	ON/OFF	0 to 1	
	0.000	59	11) Receiver ON (C)	30.640			**		
	0.000	14	12) LIR Power ON	30.76[illegible]	59(3)	RLIRS	ON/OFF	0 to 1	
	0.000	18	13) LNMS Power ON (C)	30.890			**		
	0.000	20	14) LNMS Operate	31.015			-		
	0.000	30	15) LSFR Power ON	31.140	59(6)	RLSFRS	ON/OFF	0 to 1	
					32	PLBUSI	Bus Current	+2.4A	Cumulative increased current due to turn on of 5 instruments.
	0.000	49	16) Stored Data OFF (J)	31.265			**		

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Post Blackout/ G Switch (Continued)	0.000	34	1) PCU Arm	31.390			-		Separation sequence verified by nature of scientific instrument data, by loss of deceleration module data (Channels 13, 10, 6 and 1), and by doppler shift after parachute deployment. Initial conditions: 67.2 km, Q = 72.6 lb/ft², M = 0.82
	0.000	34	2) PCU Arm (G)	31.515			**		
Parachute Deployment	7.250	36	3) Fire Pilot Chute Mortar Sqbs	36.640			-		
	0.000	36	4) Fire Pilot Chute Mortar Squibs (G)	36.765			**		
	7.750	41	5) Fire Aft Cover Separation Squibs	37.140			-		
	0.000	41	6) Fire Aft Cover Separation Squibs (G)	37.265			**		
	9.500	37	7) Fire Cable Cutter Squibs	38.890			-		E+37.89 sec - main parachute deployment (snatch), 67.0 km, γ = -50°, Q = 64.2 lb/ft², M = 0.78
	0.000	37	8) Fire Cable Cutter Squibs (G)	39.015			**		
	10.500	38	9) Fire Aeroshell Jettison Sqbs	39.890			-		
	0.000	38	10) Fire Aeroshell Jettison Squibs (G)	40.015			**		
Descent (46-67 km)	14.500	39	11) Fire LNMS Breakoff Cap Squibs	43.890			-		Aeroshell separated by ≥100 ft., 66.6 km
	0.000	39	12) Fire LNMS Breakoff Cap Squibs (G)	44.015			**		
	0.000	21	13) LNMS Valve Enable	44.140			-		Science operating altitude - ≈66.6 km
					63(6)	PLNTHS	ON/OFF	0 to 1	Smaller but non-zero current increase indicates that one or more window heaters have failed but command has been executed.
	0.000	56	14) Window and Prism Heaters ON	44.265					
					32	PLBUSI	Bus Current	+3.8A	
	0.000	56	15) Window & Prism Heaters ON (J)	44.390			**		
	0.000	35	16) PCU Disarm	44.515			-		

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Descent (46-67 km) (Continued)	60.750	56	1) Science Pwr Backup Relay ON	90.140	63(5)	PLSP25	ON/OFF	0 to 1	Science Reset Sequence; Automatic enable of thermal switch.
	0.000	00	2) LAS Power ON (D)	90.265			**		
	0.000	03	3) LAS Descent (D)	90.390			**		Individual instrument data will verify a transient failure during entry. Instrument data will be all zeros until appropriate backup commands are executed
	0.000	06	4) LN Power ON (D)	90.515			**		
	0.000	25	5) LGC Power ON (D)	90.640			**		
	0.000	10	6) LCPS Power ON (D)	90.765			**		
	0.000	14	7) LIR Power ON (D)	90.890			**		
	0.000	18	8) LNMS Power ON (D)	91.015			**		
	0.000	21	9) LNMS Valve Enable (D)	91.140			**		
	0.000	20	10) LNMS Operate (D)	91.265			**		
	0.000	30	11) LSFR Power ON (D)	91.390			**		
	180.750	57	12) LIR Window Heater 1st Stage ON	210.140	55(4) 12	PLHT1S PLBUS1	ON/OFF Bus Current	0 to 1 +0.8A	61.1 km, E+3.50 min. Also verified by window temperature telemetry, Channel 7
	693.500	22	13) Unused	722.890			-		
	735.500	32	14) Unused	764.890			-		
	777.500	33	15) LNMS IRR Sequence	806.890			-		50.2 km, 257 seconds before parachute jettison
	947.500	42	16) Unused	976.890			-		

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE, SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Parachute Jettison	50.500	48	1) Reset: Descent Timer to Zero	977.015			-		Thermal Switch backup (K). Switch status bit 46(2)=1. Failure of Timer reset command results in early (E+978.065 sec) parachute jettison.
	0.000	34	2) PCU Arm	977.140			-		
	0.000	34	3) PCU Arm (G)	977.265			**		
	0.000	37	4) Fire Cable Cutter Squibs (E)	977.390			**		
	0.000	38	5) Fire Aeroshell Jettison Squibs (E)	977.515			**		
	0.000	58	6) LIR Window Heater 2nd Stage ON	977.640	55(5) 32	PLHT25 PLBUSI	ON/OFF Bus Current	0 to 1 +1.4A	Also verified by window temperature telemetry, channel 7
	3.000	40	7) Unused	980.150			-		
	45.000	51	8) Unused	1022.015			-		
	87.000	62	9) Fire Parachute Jettison Squibs (3)	1067.015			-		46.9 km, Jettison verified by doppler signature.
	129.000	63	10) Unused	1109.015			-		
	0.000	44	11) Data Rate 256 bps Select (J)	1109.140			**		
	0.000	50	12) Descent Format Select (J)	1109.265			**		
	0.000	53	13) Science Power Primary Relay ON (J)	1109.390			**		
	0.000	54	14) Science Pwr Backup Relay ON (E)	1109.515			**		
	0.000	00	15) LAS Power ON (D, H)	1109.640			**		
	0.000	06	16) LN Power ON (D, E)	1109.765			**		

TABLE 5.1.3-1. (Continued)

MISSION PHASE/ INITIATION	COMMAND TIME CODE,SEC	CMD NO.	COMMAND TITLE (BACKUP DESIGNATOR)	EXECUTION TIME FROM ENTRY-SEC	VERIFICATION TELEMETRY Ch. No.	Ref. Des.	Title	Approx Change	REMARKS
Parachute Jettison (Continued)	0.000	25	1) LGC Power ON (D, E)	1109.890			**		Pressure vessel structural and thermal performance during descent is verified by telemetry of internal pressure, aft shelf temperature, and forward shelf temperature, Channels 31, 2 and 3 respectively.
	0.000	18	2) LNMS Power ON (D, E)	1110.015			**		
	0.000	20	3) LNMS Operate (D, E)	1110.140			**		
	0.000	21	4) LNMS Valve Enable (D, E)	1110.265			**		
	0.000	14	5) LIR Power ON (D, E)	1110.390			**		
	0.000	10	6) LCPS Power ON (D, E)	1110.515			**		
	0.000	30	7) LSFR Power ON (D, E)	1110.640			**		
	0.000	56	8) Window and Prism Heaters ON (J)	1110.765			**		
	0.000	55	9) RF Power Relay ON (J) (Also "Fire Gas Bottle")	1110.890			**		This happens to be a backup firing to that occurring at E-1319.5 sec.
	0.000	59	10) Receiver ON (J)	1111.015			**		
	0.000	39	11) Fire LNMS Breakoff Cap Squib (E)	1111.140			**		
	0.000	21	12) LNMS Valve Enable (E)	1111.265	63(6) 55(4)	PLHTWS PLHT1S	ON/OFF ON/OFF	1 to 0 1 to 0	Three options available via flight plug programming:
	554.500	15	13) LIR Window Heater OFF (Window and Prism Heaters OFF (1))	1531.515	55(5) 12	PLHT2S PLBUS1	ON/OFF Bus Current	1 to 0 -2.2A	1) Heater OFF at E+25.53 min. (29.4 km)
	555.500	15	14) LIR Window Heater OFF (Window and Prism Heaters OFF (1) (J))	1532.515					2) Heaters OFF at E+45.02 min. (7.4 km) 3) Heaters ON until end of mission (Option 3. is baseline - 4/24/78)
	1724.250	61	15) LIR Window Heater OFF/Window and Prism Heaters OFF (2)	2701.265					Impact at E+55.1 min.

TABLE 5.1.3-2

PROBE FAILURE MODES

DESIGNATOR USED IN MISSION SEQUENCE OF TABLE 5.1.3-1	DESCRIPTION OF FAILURE AND BACKUP PROVIDED	EFFECT ON SPACECRAFT SIGNATURE	EFFECT ON GROUND OPERATIONS
Backup B	Failure: Coast timer timeout Backup: All critical commands re-issued after deceleration switch signals entry.	No signal received on ground until after probe entry.	No signal acquisition before blackout. Acquisition after blackout will be at post-entry frequency with no period of unmodulated carrier to assist lockup. Fast ground operation is critical to maximize recovery of data.
Backup C	Failure: Opening of one of the following power relays during entry: science, RF, receiver Backup: All power relays (except those for C/DU which are a parallel redundant pair) are re-initialized after entry.	Science Power Relay: May observe peculiar science data (i.e., all zeros) from E+21 to E+30 seconds then expected data pattern will resume. Stored blackout data will be all zeros after relay failure. RF Power Relay: Delay in re-acquisition of probe signal from E+21 to E+30 seconds. Receiver Power Relay: Frequency shift in ground received RF signal from E+21 to E+30 seconds.	Science Power Relay: No effect. RF Power Relay: Delayed start of re-acquisition procedure-fast ground operation is critical. Receiver Power Relay: Offset in initial downlink frequency tracking capability or ground receiver will lose lock.
Backup H	Failure: Timed sequence does not turn off scientific instruments before high g entry. Backup: All turn off commands are repeated when acceleration switch signal is sensed.	None	None

TABLE 5.1.3-2. (Continued)

DESIGNATOR USED IN MISSION SEQUENCE OF TABLE 5.1.3-1	DESCRIPTION OF FAILURE AND BACKUP PROVIDED	EFFECT ON SPACECRAFT SIGNATURE	EFFECT ON GROUND OPERATIONS
Backup I	Failure: Acceleration switch does not actuate during entry (consequently there is no reset signal either). Backup: Switch actuation is simulated by timed signal at E+180 sec. Reset is simulated by timed signal at E+201 sec. Failure: Acceleration switch does not reset after proper actuation. Backup: Switch reset simulated by timed signal at E+37 seconds.	Actuation (and reset) Failure: LIR, LCPS, LN and LSFR data will be all zeros until E+201 seconds. LGC will not have all zero data as expected before E+30 seconds. Blackout format and 128 bps data rate will remain until E+201 instead of E+30 seconds. Bus current will be below expected value. Reset (Only) Failure: Eight second delay in format and data rate transition.	Delay in transition of format and and data rate must be accounted for in real time data processing.
Backup J	Failure: A particular command is not executed due to a random failure of the C/DU. Backup: Most commands are re-issued periodically during the sequence.	A variety of anomalies are possible depending on which command execution fails and when the next backup command is sent.	Ground may observe anomalies or there may be no effect depending on specifics of failure.
Backup K	Failure: Parachute fails to fully deploy or performance is degraded due to unexpected high altitude atmospheric constituents. Backup: Thermal switch assures jettison above 46 km.	Initiation of LIR window heater 2nd stage will be observed earlier than the expected 16.3 min. after entry. Probe impact will be earlier than the expected 55.3 min. after entry.	None
Backup O	Failure: Blow out of scientific instrument primary fuse due to transient power surge at entry or parachute deployment. Backup: A parallel power bus and all individual scientific instrument commands are resent approximately one minute after parachute deployment.	Particular instrument's data stream will be all zeros until the backup fuse is connected. Then normal data stream will be resumed. Bus current will be below expected value.	None

TABLE 5.1.3-2. (Continued)

DESIGNATOR USED IN MISSION SEQUENCE OF TABLE 5.1.3-1	DESCRIPTION OF FAILURE AND BACKUP PROVIDED	EFFECT ON SPACECRAFT SIGNATURE	EFFECT ON GROUND OPERATIONS
Backup E	Failure: Transition of a relay or transient instrument short during parachute jettison. Backup: All power relay and instrument commands are resent immediately after parachute jettison.	Affected data channels will be all zeros for about 100 seconds until reset. Bus current will be below expected value.	None
Backup F	Failure: C/DU initial conditions circuitry does not implement desired initial data format or data storage mode. Backup: The desired initial conditions are established by command.	None	None
Backup G	Failure: Random failure of a pyrotechnic firing command. Backup: All firing commands (except parachute jettison) are sent twice with 0.125 seconds separation between primary and backup command. There is no backup execution of parachute jettison firing command.	None	None

TABLE 5.1.3.1-1

PREDICTED LARGE PROBE RECEIVE AND TRANSMIT FREQUENCIES

	RECEIVE (BEST-LOCK) AT PRE-TIMEOUT MHz	*TRANSMIT (AUX. OSCILLATOR) AT TIMEOUT MHz
Nominal	2210.321150	2291.746500
Tolerance	±.010000	±.008000

*Listed transmit frequency applies only if the receiver fails to acquire the uplink signal between Pre-timeout and Timeout.

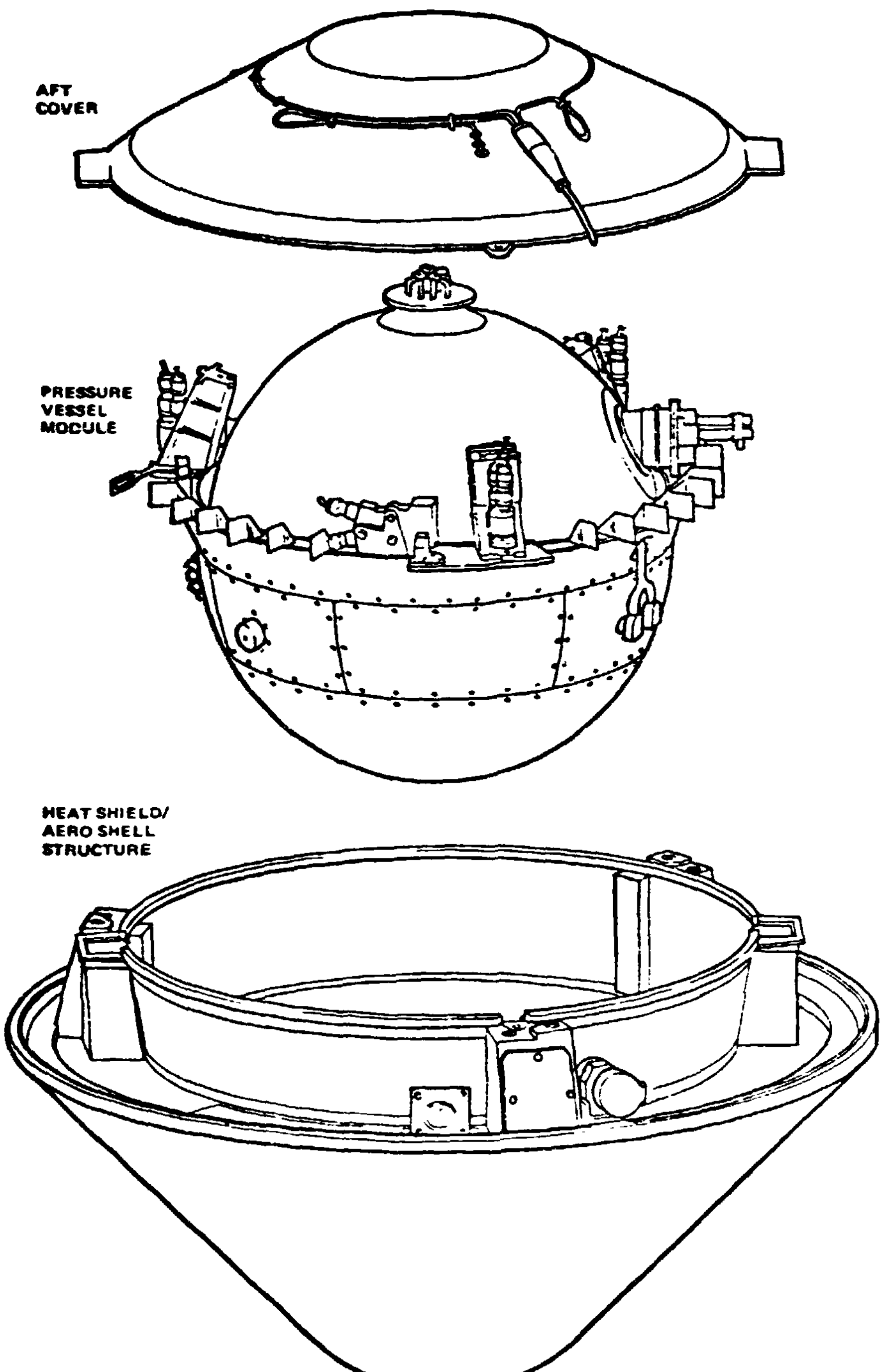

Figure 5.1.1-1. Large Probe Spacecraft (Exploded View)

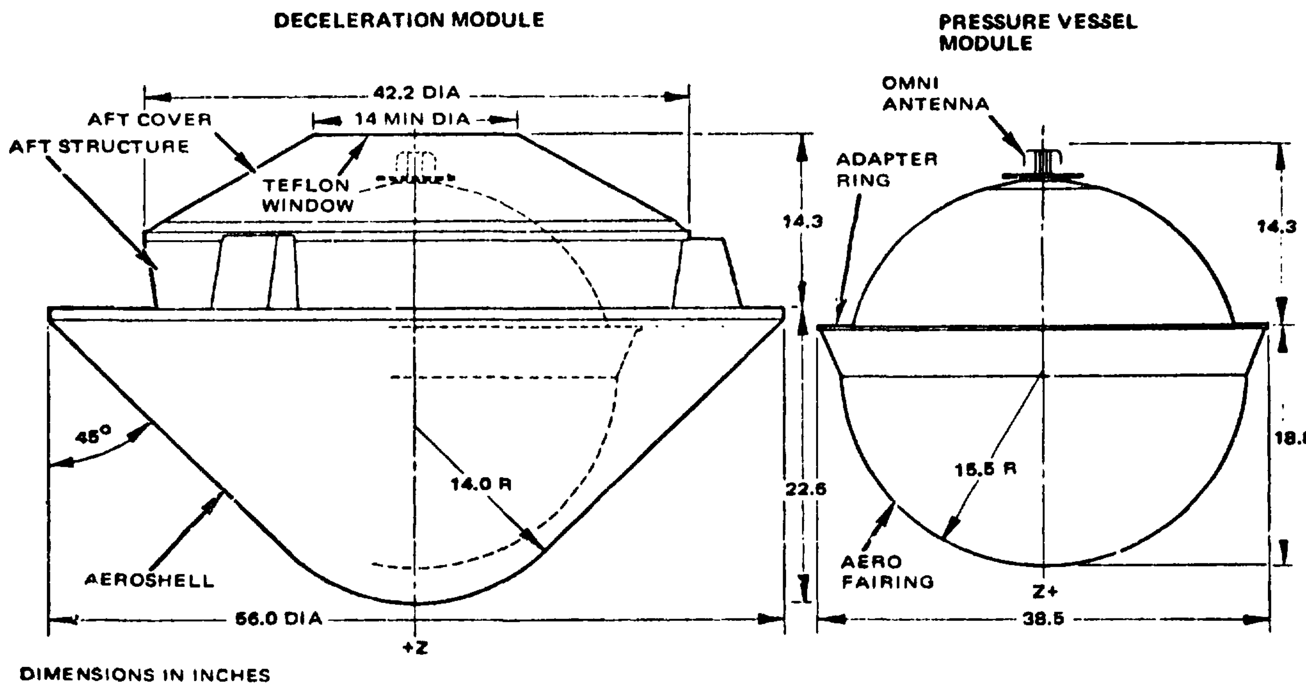

Figure 5.1.1-2. Large Probe Deceleration Module and Pressure Vessel Module Envelopes

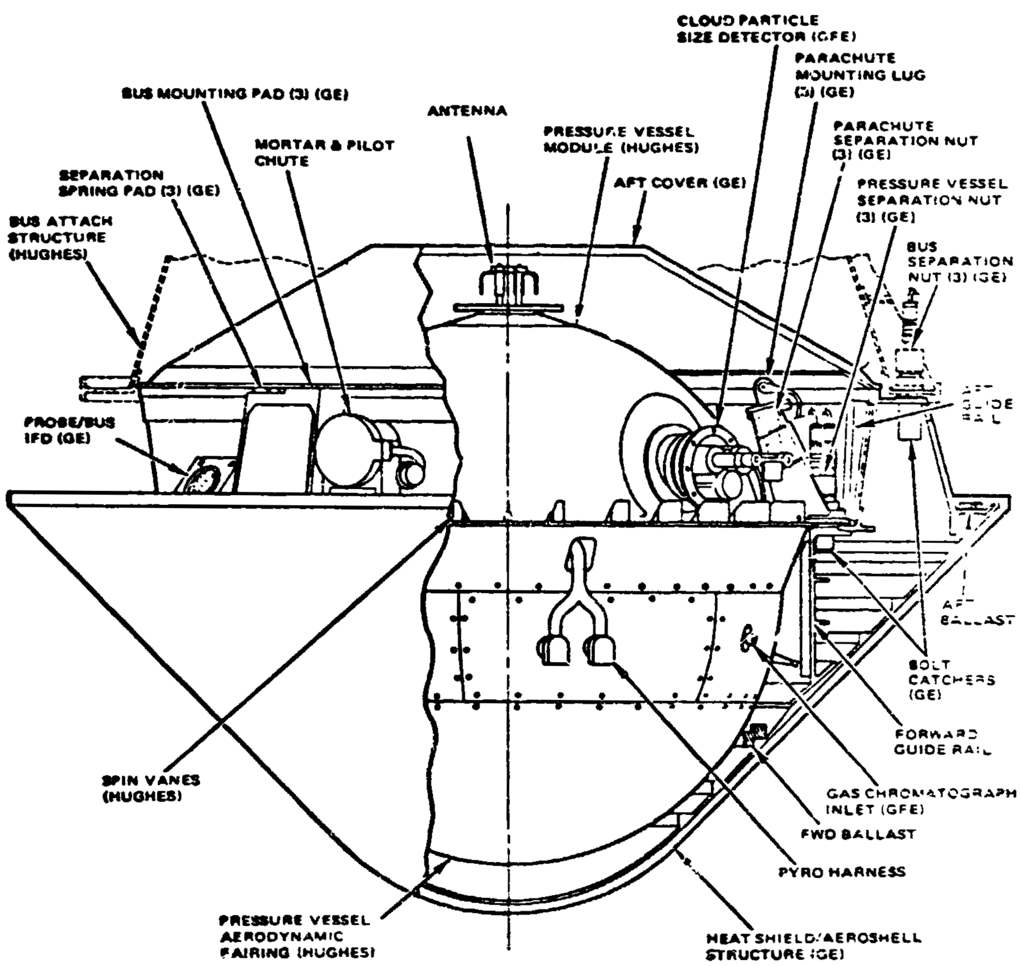

Figure 5.1.1-3. Large Probe Spacecraft (Looking Inboard at θ -330°)

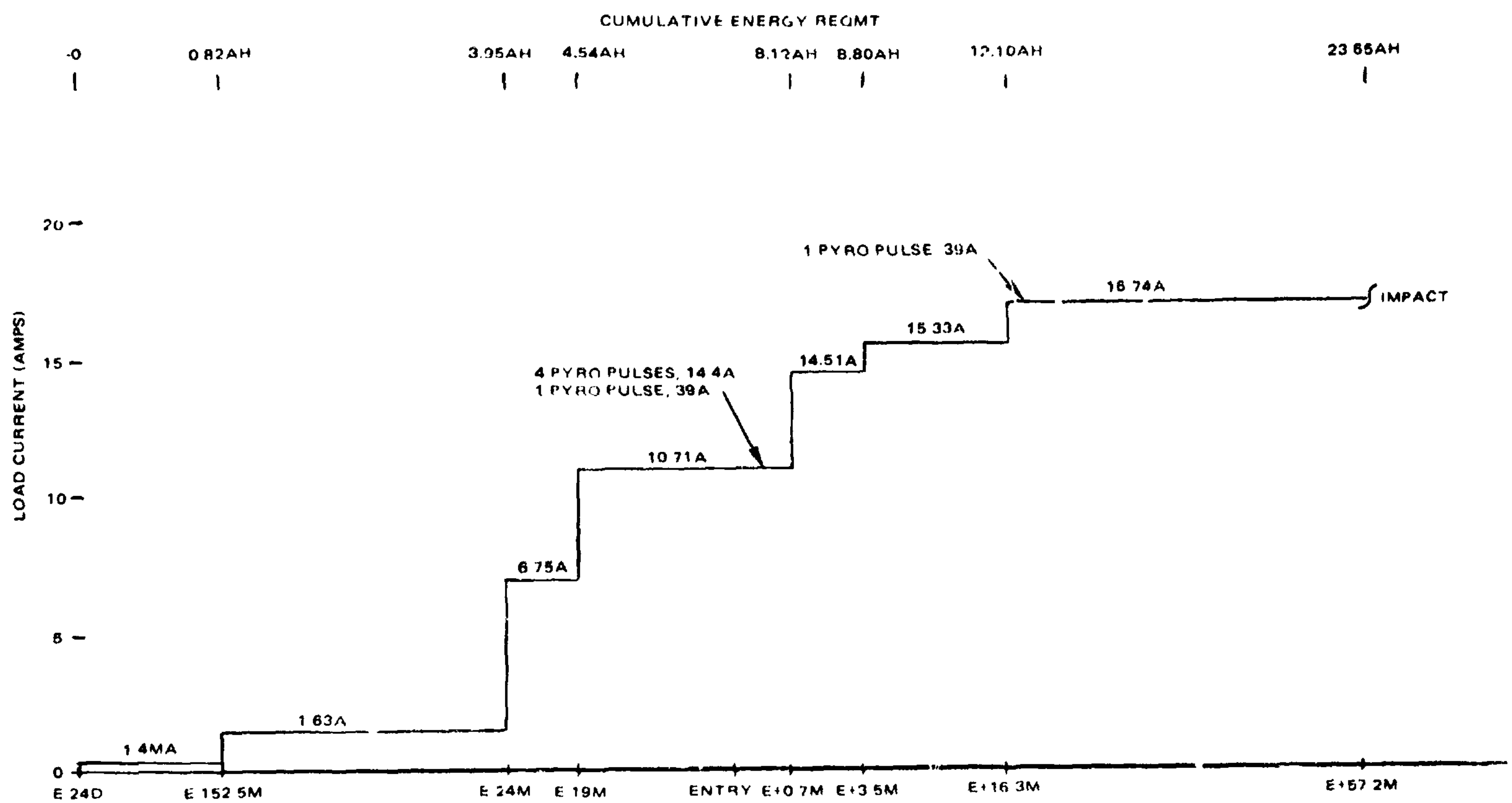

FIGURE 5.1.1-4. LARGE PROBE BATTERY CURRENT/ENERGY REQUIREMENT VS MISSION TIME

Section No. 5.1.3.2
Doc. No. PC-403
Orig. Issue Date 5/22/78
Revision No.

Revision

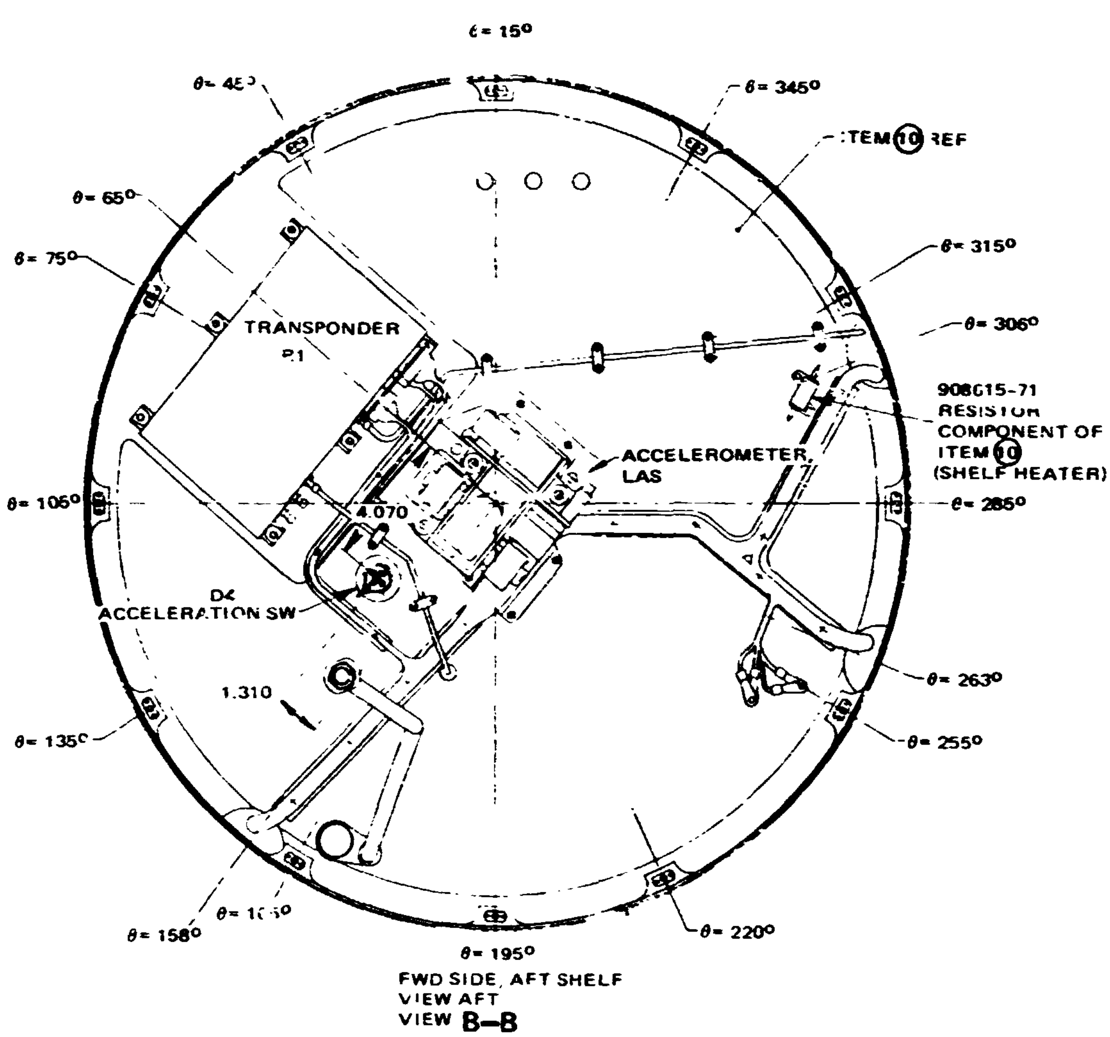

FIGURE 5.1.1-6 LARGE PROBE FORWARD SIDE, AFT SHELF

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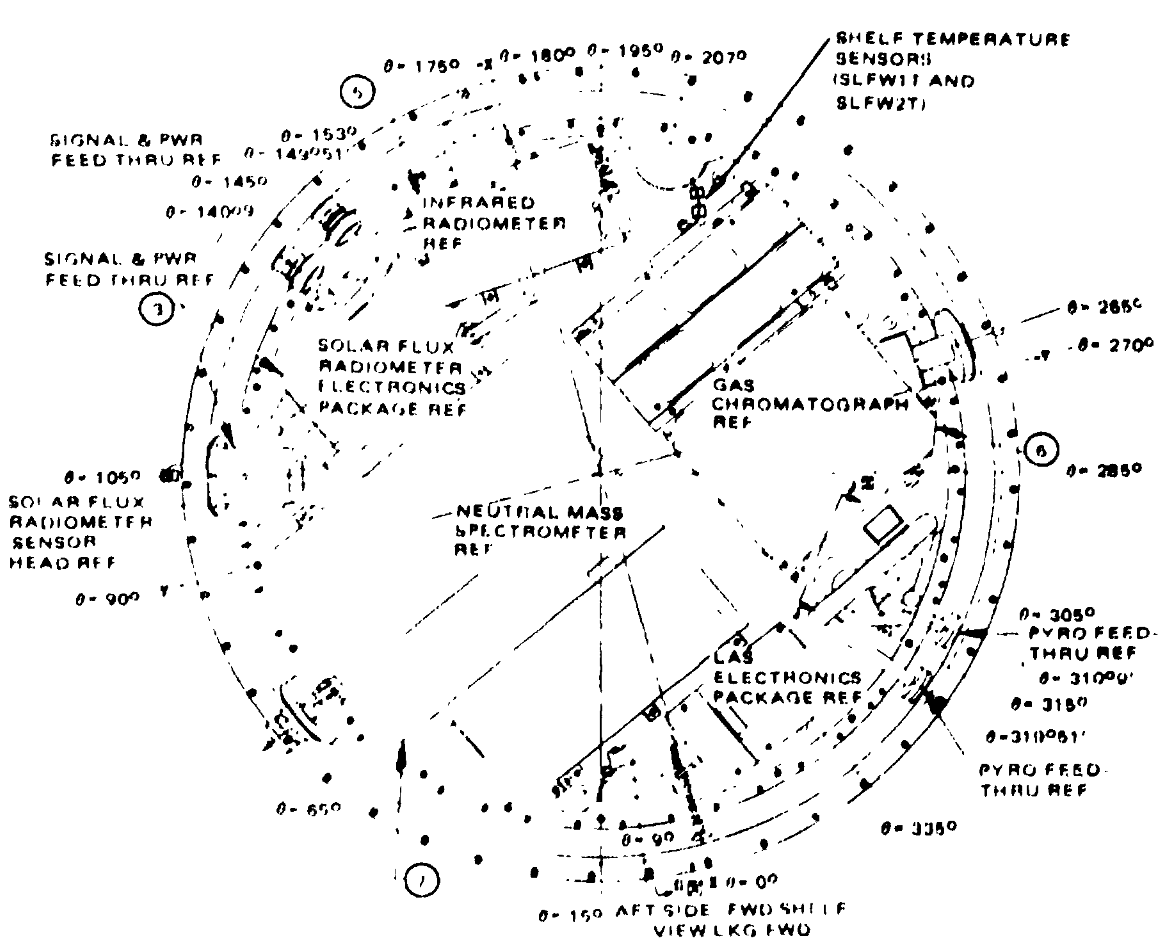

FIGURE 5.1.1-7 LARGE PROBE AFT SIDE, FORWARD SHELF

Revision

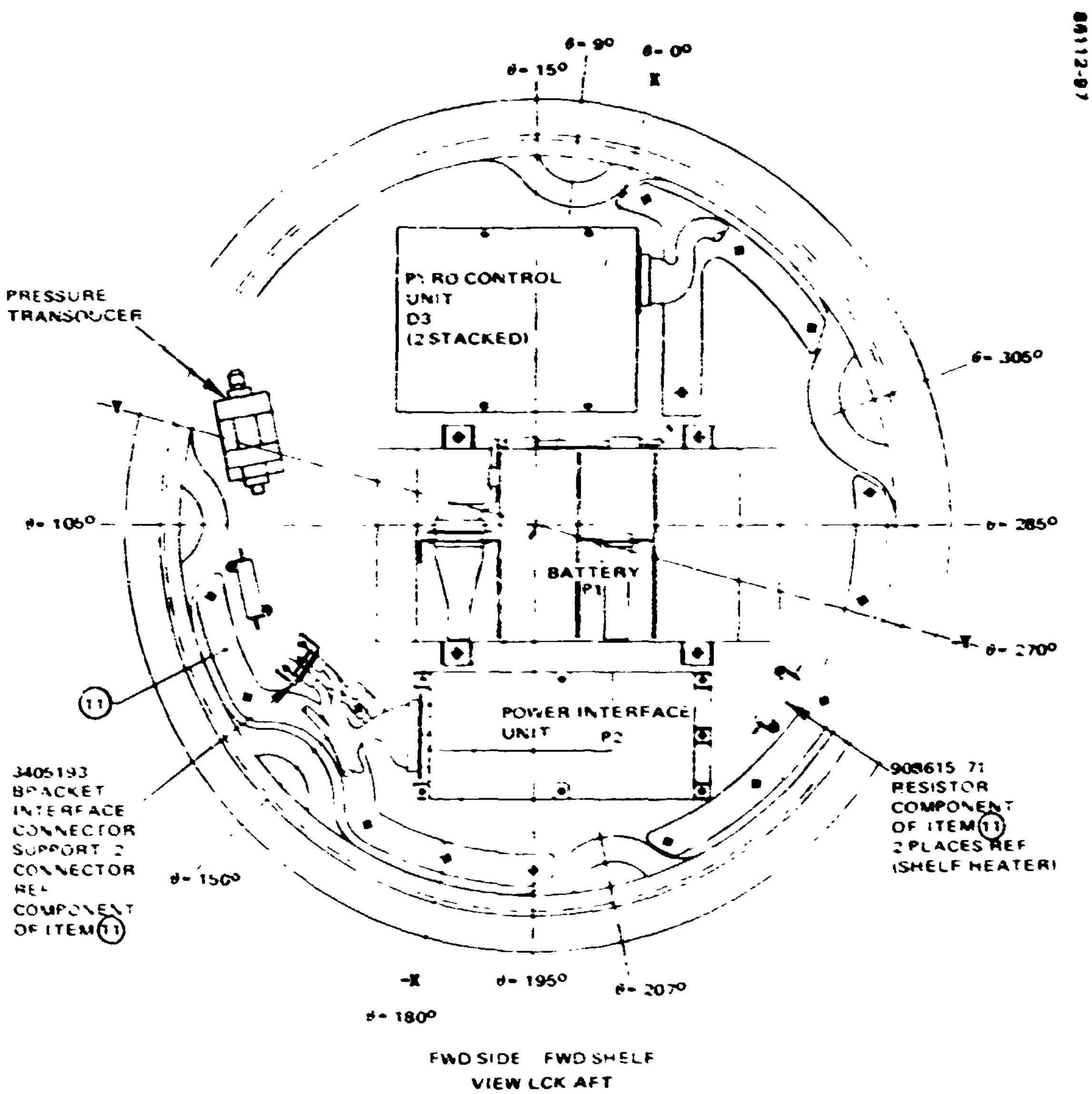

FIGURE 5.1.1-8 LARGE PROBE FORWARD SIDE, FORWARD SHELF

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****                                 ****
****   This Figure is a Foldout.     ****
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****         See APPENDIX C          ****
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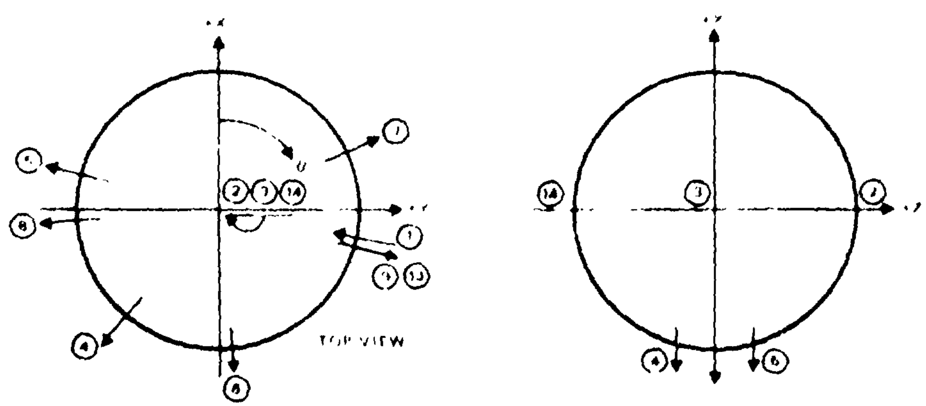
Figure 5.1.2.2-1



DEFINITIONS

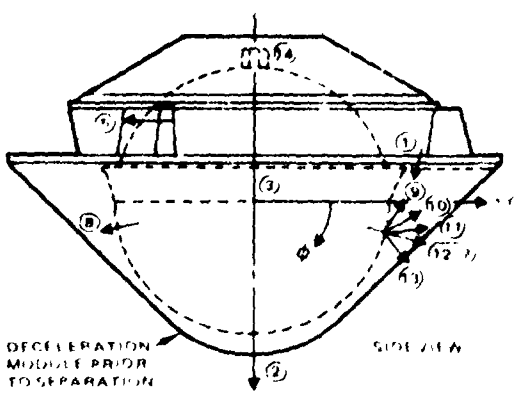
θ - AZIMUTH ORIENTATION MEASURED IN A POSITIVE SENSE ABOUT +Z AXIS FROM +X AXIS

φ - ELEVATION ORIENTATION MEASURED IN A POSITIVE SENSE ABOUT +X FROM +Y AXIS

Z - STATION MEASURED ALONG Z AXIS FROM 0.0 REFERENCE AT AFT FACE OF FORWARD HEMISPHERE MOUNTING INTERFACE FLANGE

* NOTE Δr - OFFSET FROM Z AXIS

86112 106



REF	FEATURE	ORIENTATION			FIELD OF VIEW		HUGHES DETAILED DRAWING REFERENCE
		θ (DEG)	Z (IN)	φ (DEG)	Δθ (DEG)	Δφ (DEG)	
1	LAS TEMP SENSOR	101	5	110			X3406300
2	LAS PRES INLET	Δr* 0	1	90			3385210 700
3	LAS ACCELEROM ACC	Δr* 0.10	1				3497853
4	LN VIEW AXIS NO. 1 / NO. 2	220	4.4	180	±5 / ±16	±2.16	3385922 400
5	LCPS SENSITIVE AXIS	285	6.3	180			3385923 400
6	LIR VIEW AXIS	175	+4	0	±12.5	±65	3385924 400
7	LNMS INLET	65	+1	13			3385925 400
8	LGC INLET	265	+3	167			3395928 400
9	LSFR NO. 1			62.5			
10	NO. 2			30			
11	NO. 3	105	+3	6.5	±5.05	±5.05	3385927 400
12	NO. 4			12.2			
13	NO. 5			52.1			
14	ANTENNA	Δr* 0	1	270°		±70°	

FIGURE 5.1.2.3.2-1 LARGE PROBE SCIENTIFIC INSTRUMENT AND ANTENNA LOCATIONS AND FIELDS OF VIEW

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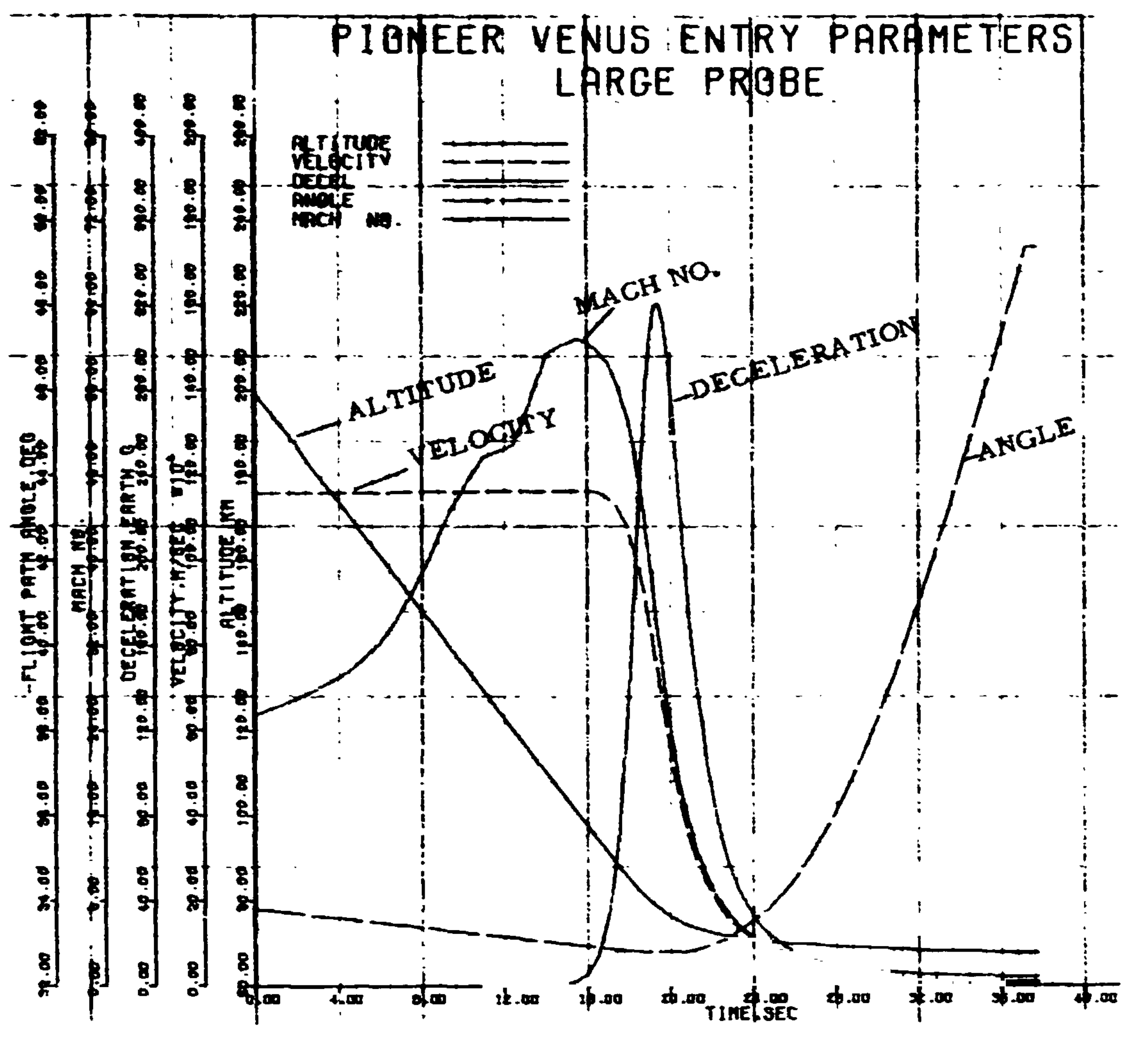

Figure 5.1.3-1. Large Probe Entry Trajectory Parameters

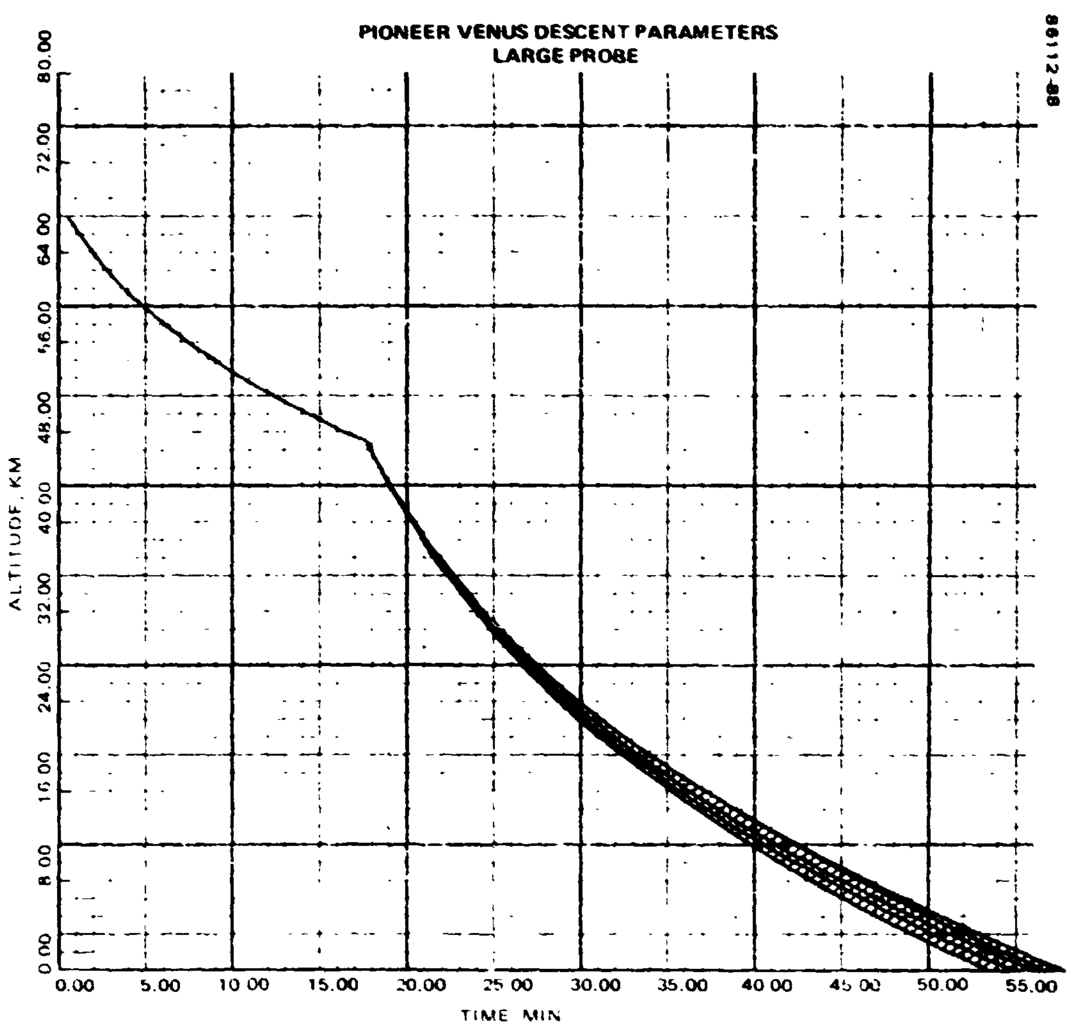

FIGURE 5.1.3-2 LARGE FROBE DESCENT ALTITUDE VS TIME FROM ENTRY

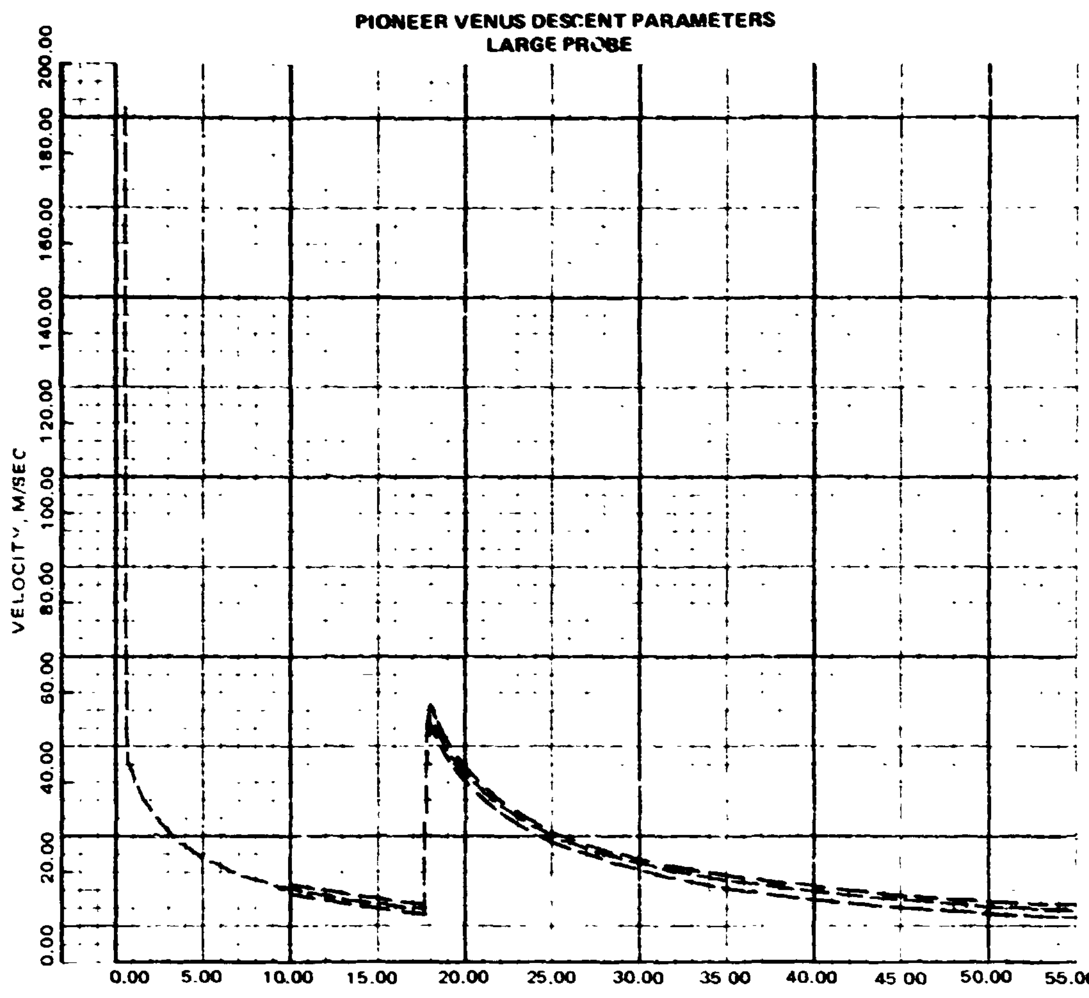

FIGURE 5.1.3-3 LARGE PROBE DESCENT VELOCITY VS TIME FROM ENTRY

5.2 SMALL PROBE DESCRIPTION

The three Small Probes are designed to enter and survive the Venus atmosphere and telemeter scientific information until impact with the Venus surface. They are attached to the Multiprobe Bus until nominally 20 days before entry into the Venus atmosphere at which time they are separated. From commanded separation until end of mission, the Small Probes are controlled by their internal coast timers, entry sequence programmers (ESP), and events sensed by an acceleration switch. A description of the Small Probe system, operation, and mission is given in Sections 5.2.1, 5.2.2, and 5.2.3, respectively.

5.2.1 Small Probe System Description. The Small Probe external configuration is shown in Figures 5.2.1-1, -2, and -3. Figure 5.2.1-1 depicts an external exploded view of the separable pressure vessel module and deceleration module. All scientific instruments are contained within the pressure vessel module. Figure 5.2.1-2 indicates the dimensions of the assembled probe. The assembled probe is contained within a 30 inch diameter by 23.6 inch high envelope. Figure 5.2.1-3 presents a cutaway view of the Small Probe and identifies the significant features.

Unlike the Large Probe which has three aerodynamic configurations, the Small Probe has only one aerodynamic configuration. The deceleration module remains attached to the pressure vessel module from probe separation from the Bus until impact.

The Small Probe contains three scientific instruments to provide in situ measurement of the structure and composition of the Venus atmosphere and clouds. The function of each instrument is summarized in Table 5.2.1-1. Significant instrument accommodation features include one sampling inlet, two heated windows and two deployed booms. A pressure vessel protects the instruments and the associated engineering support subsystems during descent to the planet's surface. The titanium pressure shell maintains an internal atmosphere of Xenon at a pressure

from 4 to 30 psia. Xenon is selected for low thermal conductivity; the Small Probe scientific instruments are not affected by Xenon. Instruments and engineering units are supported by two beryllium shelves which also provide a heat sink during descent. Internal components are thermally protected from the outside temperature by a Kapton multilayer blanket.

A deceleration module insulates the payload during atmospheric entry and provides deceleration to subsonic conditions prior to instrument boom deployment between 65 and 70 km altitude depending on entry angle. A 30 inch diameter, 45 degree, blunt cone aeroshell supports a carbon phenolic heat shield which ablates during entry to provide thermal protection. An aluminum aft cover surfaced with ESM provides thermal protection of the aft hemisphere during entry. The aft cover is basically hemispherical in shape but consists of several sections to match the various protrusions of the pressure vessel module. Descent to the surface is free fall with aerodynamic stability provided by the aeroshell configuration. Positive spin i.e., greater than 1 rpm, is assured during descent by a spin vane mounted on one of the two deployed booms.

Prior to probe separation, power is provided from the Bus spacecraft solar panel. Power is supplied after probe separation (E-20 days) by an 11 amp-hour silver zinc battery which has a useful capacity (to 80% DOD) at probe separation of 5.96 amp-hours. The bus voltage is expected to be maintained within 27.6 and 29.7 vdc (25.2 and 30.8 vdc spec) during entry and descent operation. Initial connection of internal battery power is achieved by command from the Bus to a redundant pair of magnetic latching relays. On/Off control of remaining spacecraft loads is provided by additional relays. Overload protection is provided by parallel fuses.

A power load profile is given in Figure 5.2.1-4. The total load including all engineering units

and scientific instruments is illustrated from bus separation until impact.

Prior to probe separation, downlink communications is by hardwire telemetry of the probe data subcarrier to the Bus. Downlink communications during probe entry and descent is provided by a solid-state power amplifier rated at 10 watts RF and a cross dipole antenna. A minimum EIRP of 27.8 dBm/steradian is provided over communications angles (from -Z axis) of 40 to 60 degrees. A stable oscillator provides a frequency reference for the downlink.

Two data rates (64 or 16 bps) are transmitted in a convolutionally encoded PCM/PSK/PM format. Thirty-six unique data channels (16 for science; 20 for housekeeping) are formatted in three major frame formats (Upper Descent, Lower Descent, and Blackout) each containing 16 minor frames. Each minor frame consists of sixty-four 8-bit words. There is a unique 64 word subcommutated format associated with each major frame format. Seven data channels (two of which are also transmitted in the probe telemetry stream) are separately hardwired to the Bus including one serial digital channel which requires three wires (data, read envelope, read clock). A 3072 bit solid-state memory is used to store data during entry blackout and during the data rate change at 30 km altitude.

Prior to probe separation the internal sequence is inhibited by a hardwire across the IFD. During this time, control of each probe is through 28 hardwire lines from the Bus. One command function, initiation of the coast timer, is redundantly routed through two parallel wires. The command to set the coast timeout duration requires three wires (data, envelope, clock) and in addition is redundantly routed for a total of six wires.

After probe separation, the probe is controlled by coast timer, ESP, and acceleration switch and has no provision for reception of ground commands. Forty-one internal command functions

are utilized; 128 executions are implemented in eight sequences of 16 commands each. The sequence is permanently programmed into the BSP PROMs prior to unit assembly. The sequences cannot be changed by command or other means subsequent to fabrication of the C/DU. The BSP is initiated by timeout of the coast timer (or acceleration switch as a back-up). Actuation and reset of the acceleration switch initiates particular sequences. Entry and descent command timing is controlled by an internal timer.

The probes are electrically separated from the Bus by command from the Bus of individual pyrotechnic in-flight disconnects (IFD's). Mechanical separation of the three Small Probes from the Bus is achieved by simultaneous command from the Bus of individual pyrotechnic separation devices. Three pyrotechnic functions configure the probe during entry and descent and cannot be exercised while on the Bus unless the probe is on internal battery power and the IFD is separated. The firing commands are originated by the C/DU. These functions include yo-yo deployment, SN window cover deployment, and SAS and SNFR boom deployment.

The locations of units on the forward and aft shelves are shown in Figure 5.2.1-5 through 5.2.1-8. The figures depict forward and aft views of each shelf. The mid bay, including the forward side of the aft shelf and aft side of the forward shelf, is shown to consist primarily of engineering instrumentation. The remaining forward side of the forward shelf is dominated by the probe battery. Scientific instrument electronics are shown to be distributed throughout the probe. The SN electronics are mounted on the aft side of the aft shelf, the SAS electronics are mounted on the aft side of the forward shelf, and the SNFR electronics are mounted on the forward side of the forward shelf.

5.2.2 Small Probe Operation. There is no external control of the Small Probes after they are separated from the Bus; the operational

characteristics prior to separation are emphasized in this section.

5.2.2.1 Capabilities and Limitations. Once the Small Probes are separated from the Bus there is no external command capability. In addition, there is no telemetry from the probes throughout the 20 day coast period. Small Probes telemetry is transmitted only during the final 1-1/2 hours of the Small Probes mission (pre-entry, entry and descent). The expected spacecraft signature during this 1-1/2 hour period is included in the Small Probe entry and descent sequence, Table 5.2.3-1.

Prior to separation, operation of the Small Probes consist of (1) periodic turn-on to checkout instruments and subsystem operation, and (2) continuous ON period of 25 days just prior to probes' release of the stable oscillator in each small probe. This 25-day "bakeout" period is done to insure that each small probe's stable oscillator will meet specified performance (Reference: Paragraph 1.5.34). The detailed command sequence for initiating and sustaining the "bakeout" period is contained in Table 4.2.2-2. Checkout limitations are described in Section 5.2.2.1.2. The capabilities and limitations of the activites required for separation of the probes from the Bus are discussed below and in Section 4.1.2.

5.2.2.1.1 Interplanetary Cruise. Except for brief periods of probe checkout discussed below in 5.2.2.1.2 probe operations capability during interplanetary cruise is limited to application of power to shelf heaters and monitoring the shelf and battery temperatures. One heater on the forward shelf of each probe is provided power from the Bus on lines separate from checkout power. These heaters are powered on and by command of relays on the Bus. Each Small Probe forward shelf heater has a separate power line and switching relay on the Bus. A separate telemetry channel indicates the temperatures of each shelf. This telemetry requires no external power; it is conditioned by the Bus spacecraft and is

available continuously during the cruise phase. The locations of the forward shelf heater and temperature sensors are shown in Figures 5.2.1-5 and 5.2.1-7. Two temperature sensors are located on each shelf. (SXAF1T, SXAF2T, SXFW1T, and SXFW2T for aft shelf and fwd shelf respectively. X = 1, 2, or 3 for Small Probes 1, 2, and 3 respectively). One sensor on each shelf (SXAF1T or SXFW1T) is wired to a Bus DIM; the other sensor on each shelf (SXAF2T or SXFW2T) is wired to the probe C/DU. The battery temperature sensor (PXBATT) is mounted internally in the battery pack and is wired to a Bus DIM.

5.2.2.1.2 Probe Checkout. This section discusses the operational capabilites and limitations of Small Probe checkout while the probes are attached to the Bus. Instrument checkout data will also be telemetered by the probes just before entry but no external operational control is possible at that time.

5.2.2.1.2.1 Thermal Constraints. Probe checkout can be implemented early in the cruise phase because the temperatures of the probes are expected to be above the minimum operating limit (-4°F shelf temperature for telemetry channels S1AF1T, S1FW1T, S2AF1T, S2FW1T, S3AF1T, and S3FW1T), even with the probes shelf heaters off. Temperatures increase as the Multiprobe gets closer to the sun. Any one or more scientific instruments on any Small Probe may be operated indefinitely during checkout of that probe as long as [SXFW1T AND SXFW2T AND PXBATT are all ≤ +85°F] AND [SXAF1T AND SXAF2T are both ≤ +122°F] where X = 1 or 2 or 3 for SP1 or SP2 or SP3 respectively. Once any limit is reached the equipment should be turned OFF, and checkout of that probe should not be resumed until the telemetered temperature that indicated the limit level has decreased by ≥ Δ5°F.

5.2.2.1.2.2 Command and Telemetry. Twenty-eight commands are available to each Small Probe for use during probe checkout. These commands are described in PC-455, Reference: Paragraph 1.5.1. All commands are hardwired directly from a Bus COP. The commands can be generated in real time from the ground or can be stored in the Bus command memory for subsequent execution. Command timing resolution from the Bus command memory is 0.125 seconds. Diagrams of the operational flow of each command, the interactions of commands, the required power signals, and the telemetry verification of commands are given in Figure 5.2.2.2-1.

Forty-one unique telemetry channels are available from each Small Probe to monitor probe status during checkout. They are available through Bus DIM's only, through the probe data stream only, or through both paths. These signals are described in PC-454, Reference: Paragraph 1.5.2, according to whether they are transmitted to the probe data stream that modulates the probe subcarrier, or hardwired to the Bus DIMs. Further identification is made in the command and telemetry flow diagrams of Figure 5.2.2.2-1. Real-time telemetry of the probe data stream can be transmitted at 64 or 16 bps in any one of three data formats. Telemetry of the data channels which are wired directly into a Bus format rather than the probe C/DH telemetry stream can be transmitted at any Bus data rate from 8 to 2048 bps as long as the Bus data link margin is adequate. There is no data storage capability on the Bus. Probe data storage is not planned for use during checkout.

5.2.2.1.2.3 Communications. Telemetry during probe checkout utilizes the Bus downlink only. The Bus carrier is modulated with the selected probe subcarrier and a Bus subcarrier consisting of the selected Bus format. The output power is either 10 or 20 watts. A direct probe signal is not expected to be detectable on the ground; therefore, probe communications subsystem operating characteristics cannot be determined. The probe communications subsystem may be turned

on during checkout and the associated current dissipation used to indicate subsystem status.

5.2.2.1.2.4 Power. Probe checkout power is provided from the Bus solar panel and, if required, from the Bus battery. The probe battery is not connected until final preparation for separation. Near Earth, low solar intensity and corresponding reduced solar panel output limits probe checkout capability. At about L+60 days, 35 watts of solar panel power is available for probe checkout assuming the full specified 30 watts of Bus science power is simultaneously drawn. If the Bus scientific instruments are not powered during probe checkout, a total of 65 watts of power is available. In addition, energy may be extracted from the Bus battery to support a higher checkout power for a limited period. Even with 35 watts, all the instruments on a single Small Probe can be powered indefinitely for checkout except for the thermal limit after targeting reorientation as discussed in section 5.2.2.1.2.1. There is only one data line available for probe checkout data and external multiplexing from several probes is not possible. There is, therefore, no need to power more than one probe at a time.

The expected load current for each probe unit is given in Table 5.2.2.1.2.4-1. The load current for each scientific instrument is given in Table 5.2.2.3.1.3-1.

5.2.2.2 Subsystem Operability. Figure 5.2.2.2-1 illustrates the flow of externally generated commands within each Small Probe. Internal command generation after the probes are separated from the Bus is not considered. The flow of external probe commands through the Bus is not shown in detail, i.e., from reception by the Bus receiver through transmission across the IPD. Because the three Small Probes are functionally identical, only one (Small Probe 1) is illustrated. The command and telemetry nomenclature for the other probes are described in detail in PC-455, (Reference: Paragraph 1.5.1) and PC-454 (Reference: Paragraph 1.5.2) respectively.

Figure 5.2.2.2-1 traces the command signals from the hardwire input to the point of execution. All other signals, command and power, are indicated which are required before the command path is closed. Telemetry points are indicated which verify activity along each command path. Additional telemetry channels are indicated which do not refer to the indicated commands and are not directly related to probe checkout. These channels are included because they are available during checkout if desired.

Two types of telemetry channels include those available directly across the In-Flight Disconnect (IFD) bypassing the C/DU and those available through the hardwired probe telemetry stream from the C/DU. The two types are identified in the figure according to the two indicated paths: one directly to a Bus Data Input Module (DIM) across the IFD and the other to the C/DU in one or more of three data formats.

5.2.2.2.1 Command/Data Subsystem. The nine (9) commands possible from the Bus to the command/data subsystem of each Small Probe are traced in Figure 5.2.2.2-1. The two commands to the coast timer are redundantly routed through two Bus COMs. Six associated telemetry channels include one transmitted directly to the Bus and five transmitted within the probe telemetry stream, assuming use of the Small Probe upper descent data format. Memory Read Out (MRO) is also indicated. The coast timer commands are significant because they are not for probe checkout but are required to configure the Small Probes prior to separation.

To minimize the number of separate wires across the in-flight disconnect, four external command functions are not directly available, including selection of 64 bps which also turns on the subcarrier, selection of the upper descent format, and initiation of data storage. These functions are available through initial conditions circuitry as shown in the figure. Selection of these functions is achieved by

turning the command/data subsystem power off and on.

5.2.2.2.2 Power Subsystem. The ten commands from the Bus that control the probe power subsystem are traced in Figure 5.2.2.2-1. Redundant Bus COMs are used for four of these command functions. Twelve associated telemetry points include four transmitted directly and eight transmitted within the probe telemetry stream using any probe data format. The internal power ON command is significant because it is not used for probe checkout but is required to enable probe internal power prior to separation. The internal power switch interface is unique in that the relay driver is contained in the Bus PIU and the driver output lines to the relay cross the interface.

5.2.2.2.3 Communications Subsystem. The Small Probe communications subsystem accommodates external control of the modulation index. One index is automatically selected at subsystem turn-on; the other is selected by external command. There is also separate control of the power amplifier from the remainder of the subsystem and a telemetry channel which indicates stable oscillator heater current. The three command and one telemery functions are shown in Figure 5.2.2.2-1. The communications subsystem can be turned on during checkout by command of a power relay within the PIU.

5.2.2.2.4 Other Subsystems. Additional Small Probe operational features include external power to the forward shelf heater, temperature telemetry from the shelves, telemetry from an internal pressure gauge, telemetry from the deceleration module, and boom deployment status telemetry. The shelf heater is commanded ON and OFF via a switch within the Bus as appropriate during the cruise mission. The ON/OFF commands are routed through redundant Bus COMs to the Bus PIU. The shelf heater command, power, and telemetry lines are depicted in Figure 5.2.2.2-1. Internal pressure is telemetered by the C/DU to indicate integrity of the pressure vessel seals. This telemetry channel is depicted in Figure 5.2.2.2-

1. Three deceleration module temperature channels are also indicated. These are telemetered by the C/DU to provide an indication of heatshield performance. Also shown are two telemetry channels which indicate deployment status of the SAS and SNFR booms.

5.2.2.3 Probe/Probe Instruments Interface. The electrical interface, consisting of commands, telemetry, power, and timing signals between each Small Probe and its three scientific instruments, is presented in section 5.2.2.3.1. The mechanical interface between the probe and probe instruments with respect to individual instrument orientation and field of view is presented in section 5.2.2.3.2.

5.2.2.3.1 Electrical Interface. The electrical interface between each Small Probe and the probe scientific instruments consists of 12 command lines, 16 telemetry lines, a power distribution bus and timing signals.

5.2.2.3.1.1 Commands/Telemetry/Timing Signals. Table 5.2.2.3.1.1-1 breaks down the 12 command and 16 telemetry channels available for the scientific instruments from the probe C/DU. The telemetry channels are further identified as either analog, serial digital, or bilevel. Also included in the table is identification of the timing signal provided to each instrument. Available timing signals include Read Envelope, Read Clock, Major Frame Rate, Minor Frame Rate, and 2048 Hz Clock.

5.2.2.3.1.2 Data Formats. The data from the individual scientific instruments are formatted into three minor frame formats each of which include 4 subcommutated words. The upper descent format is transmitted before entry to provide instrument checkout data and after entry during traversal of the upper atmosphere to provide measurement data from each of the three instruments. The lower descent format is initiated when the data rate is reduced from 64 to 16 bps at about 30 Km altitude and also includes data from each instrument. The analog and bilevel channels indicated in Table

5.2.2.3.1.1-1 are subcommutated with a sampling rate of one word every 128 seconds at 64 bps or every 512 seconds at 16 bps. Serial digital data are telemetered within the minor frame at a rate of one sample (8 bits) every 8 seconds or 32 seconds respectively. The blackout format is utilized at 64 bps during high speed entry deceleration. The blackout format includes atmospheric structure data, nephelometer calibration data, and telemetry of deceleration module temperature. Six frames of data (48 seconds) are stored during blackout and subsequently transmitted in 5 words of the upper descent format. One complete data storage readout requires 10.24 minutes. The data storage is used again to store 6 frames of data (192 seconds) at the time of data rate transition from 64 to 16 bps. The previously stored blackout data are written over at this time. The second playback is accomplished via 5 words of the lower descent format which results in one complete readout in 40.96 minutes. Both data playbacks automatically repeat until terminated by command or end of mission.

5.2.2.3.1.3 Power. Power to the scientific instruments is provided from the Small Probe battery via the power interface unit. Each instrument is separately fused. In addition, a parallel fuse is wired through a second power relay to provide a "one-time" reset capability in the event of a primary fuse trip. The expected load current of each scientific instrument is indicated in Table 5.2.2.3.1.3-1.

5.2.2.3.2 Mechanical Interface. The location and orientation of each instrument on each probe and the clear field of view provided for each instrument are indicated in Figure 5.2.2.3.2-1.

5.2.3 Small Probe Entry/Descent Sequence. The nominal sequence and failure modes are described ahead.

5.2.3.1 Nominal Sequence. After the Small Probes are switched via the Bus command link to internal power, the timeout duration is individually set in each coast timer and the coast timers are

initiated. The three Small Probes are simultaneously separated from the Bus at nominally E-20 days. After separation each Small Probe is individually controlled by an internal coast timer, an event sequence programmer (ESP) and specific events sensed by an acceleration switch. There is no external command capability after electrical separation.

The coast timer provides a pre-timeout signal at Entry - 201.7 ± 2 minutes to turn on the stable oscillator and battery heater. At E - 22 ± 2 minutes, the coast timer reaches the timeout duration which causes turn ON of the probe command/data unit, turn ON of the RF power relay, and turn OFF of the battery heater. The stored command sequence listed in Table 5.2.3-1 is initiated and probe RF transmission (carrier only) begins. Each Small Probe follows the same programmed entry and descent sequence. The only variation is due to the different start times and different times of acceleration switch actuation and reset. The two minute uncertainty associated with events prior to entry into the Venusian atmosphere is largely eliminated by reinitializing event timing upon actuation of the acceleration switch which signifies the start of aerodynamic braking.

Between probe separation from the Bus and initiation of RF transmission, there is no capability for determination of probe status. In addition, during the next five minutes, the data subcarrier is suppressed to enhance ground acquisition of the unmodulated downlink carrier. Telemetry of spacecraft unit data and scientific instrument data is initiated by the sequencer after the five minute period. Bilevel status telemetry; telemetry of temperatures, voltages, and currents; and RF characteristics indicate the status of the probe.

Table 5.2.3.1-1 lists the predicted downlink frequency for each probe at the initiation of RF transmission for that probe, nominally 22 minutes before that probe's entry. Subsequent tabulation of downlink frequency versus time for each probe

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will produce an uncalibrated frequency/time profile that not only includes the sought-after doppler effect, but also numerous other environmental effects. The latter effects can be eliminated by subtracting from the profile the appropriate re-drawn mean calibration curve of Figures 5.2.3.1-1 through 5.2.3.1-4. Each of these figures shows a mean calibration plot scaled to nominal entry, but uncertainty bounds scaled to worst case (E-2 minutes) entry. Each mean calibration curve should be redrawn to match the measured entry time by condensing or expanding the curve segments emanating from Step "E" until that step matches the true Entry time while the "RF" point and the "I" point stay locked relative to the time abscissa. This redrawn curve should then be subtracted from the appropriate measured frequency/time profile to produce the calibrated frequency/time profile that includes only the doppler effect.

The probe mission phases after coast timer timeout include: 1) calibration of the scientific instruments prior to entry, 2) blackout during entry when all data are stored and the ground loses the probe RF signal, 3) scientific instrument boom and cover deployments, 4) upper altitude descent at a data rate of 64 bps, and 5) lower atmosphere descent at a data rate of 16 bps. Impact occurs at approximately E + 57 minutes.

The nominal Small Probe entry locations are shown in Figure 2.1.1.3-1. These are "location" numbers and not hardware numbers, i.e., the hardware unit known as Small Probe 1 will not necessarily be targeted for the Small Probe 1 location shown in Figure 5.2.3-1. Entry trajectory parameters for these three entry locations are shown in Figures 5.2.3-1, 5.2.3-2, and 5.2.3-3. The corresponding nominal entry flight path angles are -69.8, -40.4, and -23.5 degrees respectively. The assumed entry velocity and ballistic coefficient are defined in the next paragraph. Representative descent trajectory parameters are shown in Figures 5.2.3-4 and 5.2.3.-5. Since there are no significant changes

in these parameters for the different entry flight path angles, only one entry angle, -69.8 degrees, is shown.

Table 5.2.3-1 indicates the time from entry of each command and the altitude and other trajectory parameters at significant milestones. The trajectory parameters and timing are indicated for the two extremes of flight path angle at entry of -20.0 and -75.0 degrees. The assumed entry velocity is 11,600 m/sec at 200 KM altitude. An entry ballistic coefficient of 39.41 lbs/ft^2 is assumed. The timing is based on an estimated maximum probe weight at entry of 203.13 pounds, and descent weight of 195.72 pounds. The assumed descent aerodynamic properties are a drag coefficient of 0.76 and a diameter of 30.0 inches.

The sequence indicates an option to deploy the SN window covers at either 5 or 10 seconds after acceleration switch reset. The later option provides additional calibration time employing the window mounted calibration target. However, about 0.8 kilometers of descent realtime data are sacrificed if the second option is selected. The flight plug is presently wired to implement the earlier option.

The sequence also indicates options to turn off the SN window heater at E + 18.55, E + 28.55, and E + 48.55 minutes. The flight plug presently jumpers the first of these options. The final selection depends on final determination of probe battery margin.

Table 5.2.3-1 indicates when particular telemetry channels will change value to verify that a particular sequence event has occurred. In addition, characteristics of the received RF signal will provide indication of turn on of the RF equipment, initiation of subcarrier modulation, entry blackout, and impact. Post real time analysis of the received RF waveforms and signal strength will assist in determination of atmospheric properties including turbulence and winds.

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Many of the sequence command executions are not required for nominal operation but provide backup. Backup commands are given a reference letter corresponding to each specific failure mode. The failure modes associated with each reference letter are described in section 5.2.3.2 ahead. The "J" reference letter identifies command executions which are not associated with a particular failure mode but which provide backup to random failure of a command execution.

5.2.3.2 Failure Modes Although the Small Probe is basically a single string non-redundant configuration, various backup capabilities of particular components have been utilized. In particular, 1) the acceleration switch provides a backup to failure of the coast timer (Backup B), 2) commands reestablish the configuration if an inadvertent relay transition has been caused by the high-g entry loads (Backup C), 3) a secondary scientific instrument power bus reconnects instruments that have experienced a transient short during entry (Backup D), and 4) timed commands are provided as backup for acceleration switch failure (Backup I).

These backup modes are summarized in Table 5.2.3-2. The change in spacecraft signature is indicated, and the implications on ground operations are summarized. The recognition of these peculiar signatures will enable identification of the failure and what backup has occurred.

Several additional backup modes do not significantly change the spacecraft signature and in no way alter ground operations. These include: 1) command backup of the C/DU initial conditions circuitry (Backup F), 2) dual pyrotechnic arm and fire commands to backup random failure of a single command (Backup G), and 3) acceleration switch backup of a timed command to turn off the SNFR prior to entry (Backup H). For completeness, these backup modes are included in Tables 5.2.3-1 and 5.2.3-2 along with "backup J" which, as described above, provides backup to a random failure to execute a particular command. The designators "Backup A" and "Backup E" are not used.

TABLE 5.2.1-1

SMALL PROBE SCIENTIFIC INSTRUMENT SUMMARY

NAME OF INSTRUMENT	REFERENCE DESIGNATOR	FUNCTION
Comparative Atmosphere Structure	ARC/SAS	Measure temperature, pressure and acceleration.
Nephelometer	ARC/SN	Measure cloud particulate density distribution.
Net Flux Radiometer	WISC/SNFR	Measure distributions of radiative heat transfer.

TABLE 5.2.2.1.2.4-1

CHECKOUT LOAD CURRENT FOR SMALL PROBE UNITS

POWER RELAY	UNIT NAME	AVERAGE LOAD CURRENT (@29 VDC)
Internal Power	Coast Timer	0.001
Stable Oscillator	Stable Oscillator	0.093 (0.202 peak)
Battery Heater	Not Accessible from Bus	N/A
C/DU and RF	Command/Data Unit	0.271
	PCU	0.000
	Pressure Gauge	0.015
	PIU	0.023
	Exciter	0.127
	Subtotal	0.436
	Power Amplifier (requires separate command)	1.600
	Total C/DU and RF Bus	2.036
Science Primary	Scientific Instruments (Initial current spike with no residual load current. Individual instrument load currents given in Table 5.2.2.3.1.3-1	0.000 (Approximately 1 amp. peak - pre-charge not needed)
Science Backup	Not Accessible from Bus	N/A
Window Heater	SN Window Heater	1.053

TABLE 5.2.2.3.1.1-1

SCIENCE/C/DU SIGNAL INTERFACE LINES

Instrument	CMDS From C/DU	Telemetry Channels To C/DU			Timing Signals				
		Analog	Serial Digital	Bilevel	Read Envelope	Read Clock	Major Frame Rate	Minor Frame Rate	2048 Hz Clock
Comparative Atmosphere Structure	5	1	1	1	1	1	1	1	1
Nephelometer	2	4	1	1	1	1	0	1	0
Net Flux Radiometer	5	2	1	4	1	1	1	1	1

TABLE 5.2.2.3.1.3-1

SMALL PROBE SCIENTIFIC INSTRUMENT LOAD CURRENT

INSTRUMENT	AVERAGE LOAD CURRENT AMPS	PEAK LOAD CURRENT AMPS
Comparative Atmosphereic Structure	0.14	0.25
Nephelometer	0.08	0.08
Net Flux Radiometer	0.10	0.18

TABLE 5.2.3-1

SMALL PROBE ENTRY/DESCENT SEQUENCE

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry-Sec.	Verification Telemetry				Remarks
					Ch. No.	Ref. Des.	Title	Approx. Change.	
Pre-Entry RF Acquisition/Coast Timer Timeout.	0.000	48	1) Reset Descent Timer to Zero	-1320.000			-		E-22 min, Automatic C/DU and RF power relay ON, Battery heater OFF. Two C/DU, RF power relays have status telemetry on Channels 55(2) & 55(3). C/DU performance indicated by oscillator temperature, Channel 0; 2 min. timing uncertainty; E=0 defined at 200 km altitude; 5 min. allowed for ground lookup of downlink.
	0.000	57	2) Stable Oscillator ON (A)	-1319.875			*		
	0.000	43	3) Subcarrier OFF	-1319.750			-		
	0.000	60	4) Power Amplifier ON	-1319.625			-		
	1.000	60	5) Power Amplifier ON (J)	-1319.000			**		
Pre-Entry Science Warmup and Calibration	300.000	53	6) Science Power Primary Relay ON.	-1020.000	55(5)	PXSP18	ON/OFF	0 - 1	E-17 min, telemetry initiates here. Each minor frame word is repeated every 8 seconds. Each subcommutated word is repeated every 128 sec.
	0.000	53	7) Science Power Primary Relay ON (J).	-1019.875			**		
	0.000	44	8) Data Rate 64 bps Select	-1019.750			-		
	0.000	58	9) High Mod. Index Select (F).	-1019.62			**		
	0.000	50	10) Upper Descent Format Select (F).	-1019.50			**		
	0.000	07	11) SN Power ON.	-1019.37	59(1)	EXSNS	ON/OFF	0 - 1	
	0.000	00	12) SAS Power ON.	-1019.250	59(0)	EXSASS	ON/OFF	0 - 1	
	0.000	10	13) SNFR Power ON.	-1019.125	59(2)	EXNFRS	ON/OFF	0 - 1	

(Continued on Next Page)

*Pretimeout signal at E-201, 7 min. automatically turns on stable oscillator and battery heater. Subsequent (after E-17 min) bilevel telemetry, bit 55(7), verifies that stable oscillator is ON but not whether initiation is by pretimeout signal or backup. Stable oscillator performance is verified by telemetry of heater current on Channel 34.

**Backup commands cannot be verified since probe is already in the related state. Verification telemetry is therefore not included in this table.

TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry-Sec.	Verification Telemetry Ch. No.	Ref. Des.	Title	Approx. Change.	Remarks
Pre-Entry Science Warm up and Calibration (Cont'd)	0.000	12	14) SNFR Heater ON.	-1019.000	59(4) 32	Lq PXBUSI	ON/OFF Bus Current***	0 → 1	First reported current ≈ 2.44 Amps
	0.000	00	15) SAS Power ON (J)	-1018.875			**		
	720.000	03	16) SAS Calibrate	- 600.000			-		E-10 Min.
Pre Entry	1020.000	11	1) SNFR Power OFF.	-300.000	59(2) 32	FXSNFRS PXBUSI	ON/OFF Bus Current	1 → 0 -0.2A	E-5 Min.
	0.000	34	2) PCU Arm	-299.875			-		
	0.000	34	3) PCU Arm (G)	-299.750			**		
	0.000	36	4) Fire Despin Device Primary Squibs	-299.625			-		
	0.000	37	5) Fire Despin Device Backup Squibs	-299.500			-		
	0.000	35	6) PCU Disarm	-299.375			-		
	0.000	35	7) PCU Disarm (G)	-299.250			**		
	0.000	4[illegible]	8) Blackout Format Select	-299.125	46(5,6)		ID	00 → 01	
	0.000	04	9) SAS Blackout	-299.000			-		Stored data are written over until E+14.68 sec. (-12.77 sec.). Stored data mode established by initial conditions and verified if telemetry status bit 46(8) = 1.
	0.000	47	10) Stored Data Initiate (F)	-298.875			**		

(Continued on Next Page)

***Any change in battery load will not only result in a change in telemetered bus current, channel 32, but also will result in a small change in battery voltage, channel 33, and a change in shelf temperature, channels 2 and 3.

TABLE 5.2.3.1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry-Sec.	Verification Telemetry Ch. No.	Ref. Des.	Title	Approx. Change.	Remarks
Pre-Entry (Cont'd)	1200,000	08	11) Unused	-120,000					1-2 Min.
	0,000	55	12) SN Window Heater ON	-119,875	55(4) 32	PXHTWS PXBUSI	ON/OFF Bus Cur.	0 → 1 +1.1A	
	0,000	44	13) Data Rate 64 bps Select (I)	-119,750			**		
	0,000	00	14) SAS Power ON (I)	-119,625			**		
	0,000	46	15) Blackout Format Select (J)	-119,500			**		
	1500,000	04	16) SAS Blackout (J)	+180,000			**		Backup initiation of next sequence.

TABLE 5.2.3-1 (Continued)

Mission Phase / Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds: γ_e = -20 Deg.	Execution Time From Entry, Seconds: γ_e = -75 Deg.	Verification Telemetry: Ch. No.	Verification Telemetry: Ref. Des.	Verification Telemetry: Title	Verification Telemetry: Approx. Change.	Remarks γ_e = -20 Deg (γ_e = -75 Deg)
Blackout G Switch	0.000	53	1) Science Power Primary Relay ON (B)	26,630	9.150			**		Accel. sw. actuation, 5.5g's occurs at E+26.73 sec. 97.9 km (E+9.09 sec 97.9 km) C/DU & RF pwr rly ON and batt. htr. OFF. Sw. status bit, 46(1)=1, not likely to be telemetered before sw. reset. Actuation verified by nom. operation after entr..
	0.000	11	2) SNFR Power OFF (B)	26,755	9.275			**		
	0.000	08	3) Unused	27,880	9.400			-		
	0.000	58	4) High Mod. Index Select (B)	27,005	9.525			**		
	0.000	46	5) Blackout Format Select (B)	27,130	9.650			**		
	0.000	00	6) SAS Power ON (B)	27,255	9.775			**		Enter blackout (0.05g) at E+21.99 sec, 115.4 km (E+7.54 sec, 115.3 km) - loss of RF signal on gnd.
	0.000	04	7) SAS Blackout (B)	27,380	9.900			**		
	0.000	05	8) SN Window Heater ON (B)	27,505	10.025			**		
	0.000	48	9) Reset Descent Timer to Zero	27,630	10.150			-		Heat shield performance during entry verified by temp. telemetry on channels 1, 13 and 14.
	0.000	44	10) Data Rate 64 bps Select (F)	27,755	10.275			**		
	0.000	4[illegible]	11) Stored Data Initiate (F)	27,880	10.400			**		
	0.000	[illegible]	12) Stable Oscillator ON (B)	28,005	10.525			**		
	0.000	60	13) Power Amplifier ON (B)	28,130	10.650			**		Peak decel. at E+32.22 sec, 80.0 km, 192g (E+11.27, 75.4 km, 550 g).
	4.000	52	14) Enable Acceleration Sw. Reset	31,630	14.750			-		
	5.000	52	15) Enable Acceleration Sw. Reset (J)	32,630	15.150			**		Exit blackout (3 km/sec) at E+35.23 sec, 75.5 km (E+12.38 sec, 70.1 km) - resumpt. of downlink recep. on ground. Downlink re-lock required.
	26.000	44	16) Data Rate 64 bps Select (I)	53,630	36,150			**		Backup initiation of next sequence.

TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds γ_e = -20 Deg.	Execution Time From Entry, Seconds γ_e = -75 Deg.	Verification Telemetry Ch. No.	Verification Telemetry Ref. Des.	Verification Telemetry Title	Verification Telemetry Approx. Change.	Remarks γ_e = -20 Deg (γ_e = -75 Deg)
Post Blackout/G Switch.	0.000	48	1) Reset Descent Timer to Zero	45.650	18.230			-		Accel. sw. reset. 5.5 g's, occurs at E+45.82 sec, 71.3 km (E+18.17 sec, 65.1 km). Sw. state verified if status bit 48(1)=0. If sw. actuation does not take place reset will not be acknowledged. Failure to execute timer reset cmd will result in early deploy. of SN window cover which can be detected in instrument telemetry.
	0.000	34	2) PCU Arm	45.775	18.355			-		
	0.000	34	3) PCU Arm (G)	45.900	18.480			••		
	0.000	56	4) SN Window Heater OFF (I)	46.025	18.605			-		
	0.000	39	5) Fire SAS and SNFR Boom Deployment Primary Squibs.	46.150	18.730	55(0)	SXASBS	SAS Boom Status	0 - 1	
	0.000	40	6) Fire SAS and SNFR Boom Deployment Backup Squibs.	46.275	18.855	55(1)	SXFRBS	SNFR Boom Status	0 - 1	
	0.000	50	7) Upper Descent Format Select	46.400	18.980			••		
	0.000	01	8) SAS Upper Descent	46.525	19.105	46(5, 6)		ID	01 - 00	Boom deploy. is at Q=157 lb/ft² M∞ = 1.80 (180 lb/ft², M∞ 1 1.00). Boom deploy. can be verified by nature of SAS and SNFR data.
	0.000	53	9) Science Power Primary Relay ON (C)	46.650	19.23[illegible]			•		
	0.000	07	10) SN Power ON	46.775	19.[illegible]5			••		
	0.000	00	11) SAS Power ON (C)	46.900	19.480	59(1)	EXSNS	ON/OFF	0 - 1	
	0.000	01	12) SAS Upper Descent (C)	47.025	19.605			••		
	0.000	10	13) SNFR Power ON	47.150	19.730			••		
	0.000	13	14) SNFR Heater and Solenoid ON	47.[illegible]75	19.855	59(2) 32	EXNFRS PXBUSI	ON/OFF Bus Curr	0 - 1 +0.3A	Window heater only off for 10 sec, not likely to be observed in telemetry.
	0.000	57	15) Stable Oscillator ON (C)	47.400	19.980	59(4)	L_f	ON/OFF	0 - 1	
	0.000	44	16) Data Rate 64 bps Select (J)	47.525	20.105	59(3)	L_e	Flip Status ••	-	Periodic change in bilevel state indicates sensor is flipping.

TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds		Verification Telemetry				Remarks
				γ_e = -20 Deg.	γ_e = -75 Deg.	Ch. No.	Ref. Des.	Title	Approx. Change.	γ_e = -20 Deg (γ_e = -75 Deg)
Post-Blackout (Continued)	0.000	58	1) High mod Index Select (J)	47.650	20.230			**		
	0.000	50	2) Upper Descent Format Select (J)	47.775	20.355			**		
	0.000	53	3) Science Power Primary Relay ON (J)	47.900	20.480			**		
	0.000	07	4) SN Power ON (J)	48.025	20.605			**		
	0.000	00	5) SAS Power ON (J)	48.150	20.703			**		
	0.000	01	6) SAS Upper Descent (J)	48.275	20.855			**		
	0.000	10	7) SNFR Power ON (J)	48.400	20.980			**		
	0.000	13	8) SNFR Heater & Solenoid ON (J)	48.525	21.105			**		
	5.000	33	9) Fire SN Window Cover Deployment Squibs (1)	50.650	23.230			-		
	6.000	33	10) Fire SN Window Cover Deployment Squibs (1) (G)	51.650	24.230			**		Two options for SN window cover deploy, corresponding to following initiation altitudes: (1) 70.52 km (64.08 km) (2) 69.80 km (63.31 km) (Option 1 is baseline 8/11/77).
	10.125	38	11) Fire SN Window Cover Deployment Squibs (2)	55.775	28.355			-		
	11.125	38	12) Fire SN Window Cover Deployment Squibs (2) (G)	56.775	29.355			**		
	0.000	55	13) SN Window Heater ON	56.900	29.480			-		Brief turnoff of SN window heater not likely to be observed due to slow sampling rate.
	12.250	35	14) PCU Disarm	57.900	30.480			-		
	17.000	49	15) Stored Data OFF	62.650	35.230	46(0)		ID	1 → 0	68.9 km (62.5 km)
	18.000	49	16) Stored Data OFF (J)	63.650	36.230			**		

TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds γ_e = -20 Deg.	Execution Time From Entry, Seconds γ_e = -75 Deg.	Verification Telemetry Ch. No.	Verification Telemetry Ref. Des.	Verification Telemetry Title	Verification Telemetry Approx. Change.	Remarks γ_e = -20 Deg (γ_e = -75 Deg)
Descent	65,000	54	1) Science Power Backup Relay ON	110.650	83.230	55(6)	PXSP28	ON/OFF	0 - 1	Science reset sequence: Individual instrument data will verify a transient failure during entry. Instrument data will be all zeros until appropriate backup commands are executed.
	0,000	07	2) SN Power ON (D)	110.775	83.355			••		
	0,000	00	3) SAS Power ON (D)	110.900	83.480			••		
	0,000	01	4) SAS Upper Descent (D)	111.025	83.605			••		
	0,000	10	5) SNFR Power OFF (D)	111.150	83.730			••		
	0,000	13	6) SNFR Heater & Solenoid ON (D)	111.275	83.856			••		
	0,000	55	7) SN Window Heater ON (J)	111.400	83.980			••		
	0,000	50	8) Upper Descent Format Select (J)	111.525	84.105			••		
	0,000	54	9) Science Power Backup Relay ON (J)	111.650	84.230			••		
	0,000	07	10) SN Power ON (J)	111.775	84.355			••		
	0,000	00	11) SAS Power ON (J)	111.900	84.480			••		
	0,000	01	12) SAS Upper Descent (J)	112.025	84.605			••		
	0,000	10	13) SNFR Power ON (J)	112.150	84.730			••		
	0,000	13	14) SNFR Heater & Solenoid ON (J)	112.275	84.855			••		
	0,000	57	15) Stable Oscillator ON (J)	112.400	84.980			••		
	0,000	60	16) Power Amplifier ON (J)	112.525	85.105			••		

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TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds		Verification Telemetry				Remarks
				Y_e = -20 Deg.	Y_e = -75 Deg.	Ch. No.	Ref. Des.	Title	Approx. Change.	Y_e = -20 Deg (Y_e = -75 Deg)
Descent	937.500	48	1) Reset Descent Timer to Zero	983.150	955.730			-		
(Continued)	0.000	47	2) Stored Data Initiate	983.275	955.855	46(0)		ID	0 - 1	
	0.000	45	3) Data Rate 16 bps Select	983.400	955.980	46(7)		ID	1 - 0	Data rate transition: 28.66 km (28.75 km). Temporary loss of telemetry lock. Each minor frame word is repeated every 32 secs. Each subcommutated word is repeated every 512 secs. First 3072 bits stored.
	0.000	59	4) Low Mod. Index Select	983.525	956.105			-		
	0.000	51	5) Lower Descent Format Select	983.650	956.230	46(5, 6)		ID	00 - 11	
	0.000	02	6) SAS Lower Descent	983.775	956.355			-		
	0.000	14	7) SNFR Lower Descent Mode	983.900	956.480	59(5)		Mode Status	0 - 1	
	0.000	47	8) Stored Data Initiate (J)	984.625	956.605			••		
	0.000	45	9) Data Rate 16 bps Select (J)	984.150	956.730			••		
	0.000	59	10) Low Mod Index Select (J)	984.275	956.855			••		
	0.000	51	11) Lower Descent Format Select (J)	984.400	956.980			••		
	0.000	53	12) Science Power Primary Relay ON (J)	984.525	957.105			••		
	0.000	54	13) Science Power Backup Relay ON (J)	984.650	957.230			••		
	0.000	07	14) SN Power ON (J)	984.775	957.355			••		
	0.000	00	15) SAS Power ON (J)	984.900	957.480			••		
	0.000	02	16) SAS Lower Descent (J)	985.025	957.605			••		

TABLE 5.2.3-1 (Continued)

Mission Phase/ Initiation	Command Time Code, Sec	CMD No.	Command Title (Backup Designator)	Execution Time From Entry, Seconds γ_e = -20 Deg.	γ_e = -75 Deg.	Verification Telemetry Ch. No.	Ref. Des.	Title	Approx. Change.	Remarks γ_e = -20 Deg (γ_e = -75 Deg)
Descent	0.000	10	1) SNFR Power ON (J)	985.150	957.730			••		Pressure vessel structural and thermal performance during descent is verified by telemetry of internal pressure, aft shelf temperature & fwd shelf temperature, Channels 31, 2 & 3, respectively.
(Continued)	0.000	14	2) SNFR Lower Descent Mode (J)	985.275	957.855			••		
	0.000	13	3) SNFR Heater & Solenoid ON (J)	985.400	957.980			••		
	0.000	57	4) Stable Oscillator ON (J)	985.525	958.105			••		
	0.000	55	5) SN Window Heater ON (1)	985.650	958.230			••		
	0.000	60	6) Power Amplifier ON (J)	986.775	958.355			••		
	0.000	47	7) Stored Data Initiate (J)	986.900	958.480			••		
	0.000	45	8) Data Rate 16 bps Select (J)	986.025	958.605			••		In addition to permanently wired option (1) which turns off the SN window htr during pyro firing are the following 4 options: (2) Heater OFF at 27.20 km (26.35 km), (3) Heater OFF at 17.83 km (17.20 km), (4) Heater OFF at 10.60 km (10.10 km), (5) Heater ON until end of mission (Opt. 2 is baseline 8/11/77).
	0.000	59	9) Low Mod. Index Select (J)	986.150	958.730			••		
	129.500	29	10) SN Window Heater OFF (2)	112.650	1085.230	55(4)	PXHTWS	ON/OFF	1 · 0	
	192.000	49	11) Stored Data OFF	1175.150	1147.730	46(0)		ID	1 · 0	
	193.000	49	12) Stored Data OFF (J)	1176.150	1148.730			••		
	429.500	62	13) Spare	1412.650	1385.230			-		
	729.500	30	14) SN Window Heater OFF (3)	1712.650	1685.230	55(4)	PXHTWS	ON/OFF	1 · 0	When window heater is turned OFF a bus current reduction of 1.1A will be observed on Channel 32.
	1329.500	31	15) SN Window Heater OFF (4)	2312.650	2285.230	55(4)	PXHTWS	ON/OFF	1 · 0	
	1929.500	63	16) Spare	2912.65	2885.230			-		Impact at 57.60 min. (E+56.35 Min).

TABLE 5.2.3-2

PROBE FAILURE MODES

Designator Used in Mission Sequence	Description of Failure and Backup Provided	Effect on Spacecraft Signature	Effect on Ground Operations
Backup B	Failure: Coast Timer time-out. Backup: All critical commands re-issued after deceleration switch signals entry.	No signal received on ground until after probe entry.	No signal acquisition before blackout. Acquisition after blackout will be at post-entry frequency with no period of unmodulated carrier to assist lockup. Fast ground operation is critical to maximize recovery of data.
Backup C	Failure: Opening of one of the following power relays during entry: Science, stable oscillator. Backup: All power relays (except those for C/DU & RF which are a parallel redundant pair) are re-initialized after entry.	<u>Science Power Relay</u>: May observe peculiar science data (i.e., all zeros) from E+35 to E+47 seconds, then expected data pattern will resume. Stored blackout data will be all zeros after relay failure. <u>Stable Oscillator Power Relay</u>: Frequency shift in ground received RF signal from E+35 to E+47 seconds.	<u>Science Power Relay</u>: No effect. <u>Stable Oscillator Power Relay</u>: Offset in initial downlink frequency must be within ground receiver tracking capability or ground receiver will lose lock.
Backup D	Failure: Blowout of scientific instrument primary fuse due to transient power surge at entry. Backup: A parallel power bus and set of fuses and all individual scientific instrument commands are resent approximately one minute after scientific instrument boom deployment.	Particular instrument's data stream will be all zeros until the backup fuse is connected. Then normal data stream will be resumed. Bus current will be below expected value.	None

TABLE 5.2.3-2 (Continued)

Designator Used in Mission Sequence	Description of Failure and Backup Provided	Effect on Spacecraft Signature	Effect on Ground Operations
Backup F	Failure: C/DU and exciter initial conditions circuitry do not implement desired initial data format, modulation index or data storage mode. Backup: The desired initial conditions are established by command.	None.	None.
Backup G	Failure: Random failure of a pyrotechnic firing command. Backup: All firing commands are sent twice with 0.125 seconds separation between primary and backup command.	None.	None.
Backup H	Failure: Timed sequence does not turn off scientific instruments before high-g entry. Backup: All turn-off commands are repeated when acceleration switch signal is sensed.	None.	None.
Backup I	Failure: Acceleration switch does not actuate during entry (consequently, there is no reset signal either). Backup: Switch actuation is simulated by timed signal at E+180 sec. Reset is simulated by timed signal at E+207 sec. Failure: Acceleration switch does not reset after proper actuation. Backup: Switch reset simulated by timed signal at E+54 seconds.	Actuation (and reset) failure: SN and SNFR data will be all zeros until E+208 seconds. Blackout format will remain until E+208 instead of E+46 seconds. Bus current will be below expected value. Reset (only) failure: Eight second delay in format and data rate transition.	Delay in transition of format and data rate must be accounted for in real time data processing.

TABLE 5.2.3-2 (Continued)

Designator Used in Mission Sequence	Description of Failure and Backup Provided	Effect on Spacecraft Signature	Effect on Ground Operations
Backup J	Failure: A particular command is not executed due to a random failure of the C/DU. Backup: Most commands are re-issued periodically during the sequence.	A variety of anomalies are possible depending on which command execution fails and when the next backup command is sent.	Ground may observe anomalies or there may be no effect depending on specifics of failure.

TABLE 5.2.3.1-1

PREDICTED SMALL PROBE TRANSMIT FREQUENCIES
AT TIMEOUT (ENTRY MINUS 22 MIN.)

	SMALL PROBE 1 (SN003 OSCILLATOR) MH_Z	SMALL PROBE 2 (SN002 OSCILLATOR) MH_Z	SMALL PROBE 3 (SN001 OSCILLATOR) MH_Z	SPARE OSCILLATOR (SN004) MH_Z
Normal*	2292.282158	2292.437486	2291.393850	2291.552197
Tolerance*	$\pm$.000300	$\pm$.000400	$\pm$.000500	$\pm$.000300

*Nominal frequencies and tolerances listed are based on measured performance over a two-year period ($>$10% margin included).
Specified tolerance is $< \pm .002300$ MH_Z.

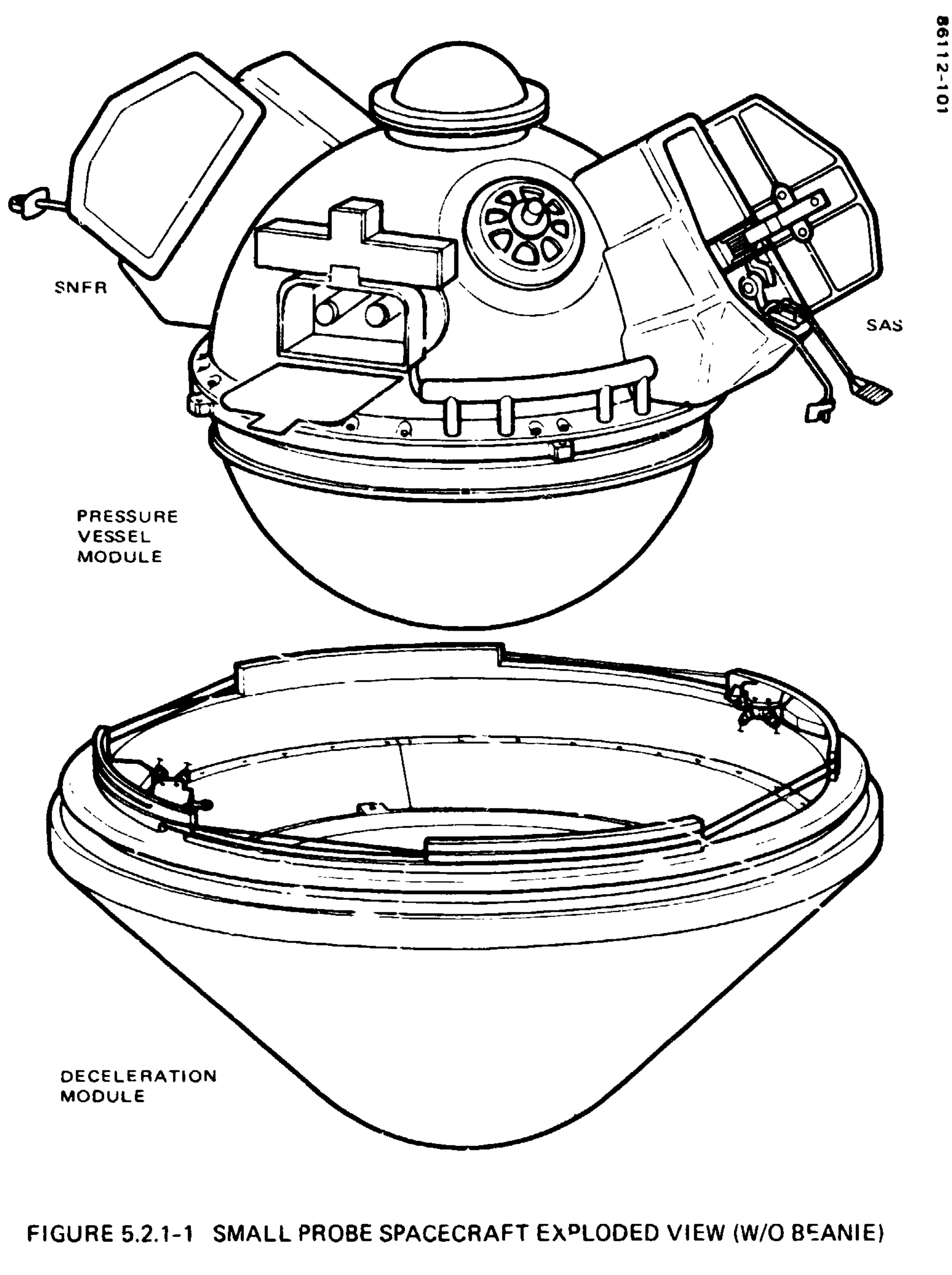

FIGURE 5.2.1-1 SMALL PROBE SPACECRAFT EXPLODED VIEW (W/O BEANIE)

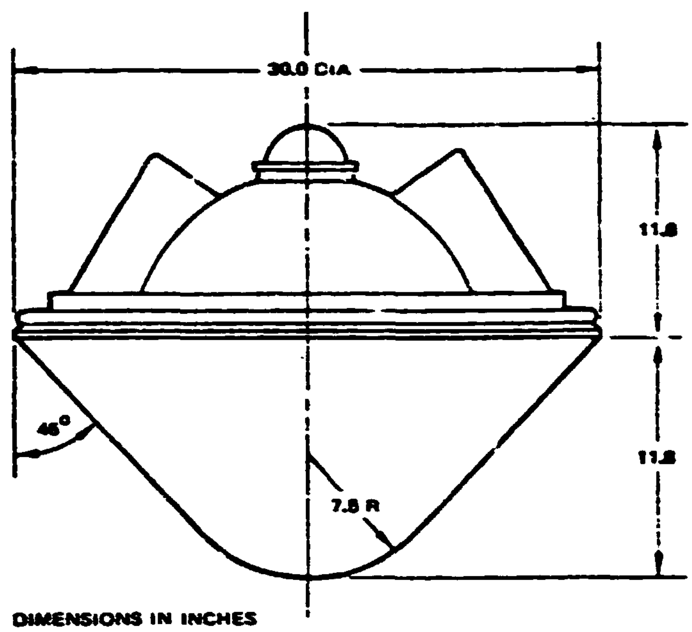

Figure 5.2.1-2. Small Probe Envelope

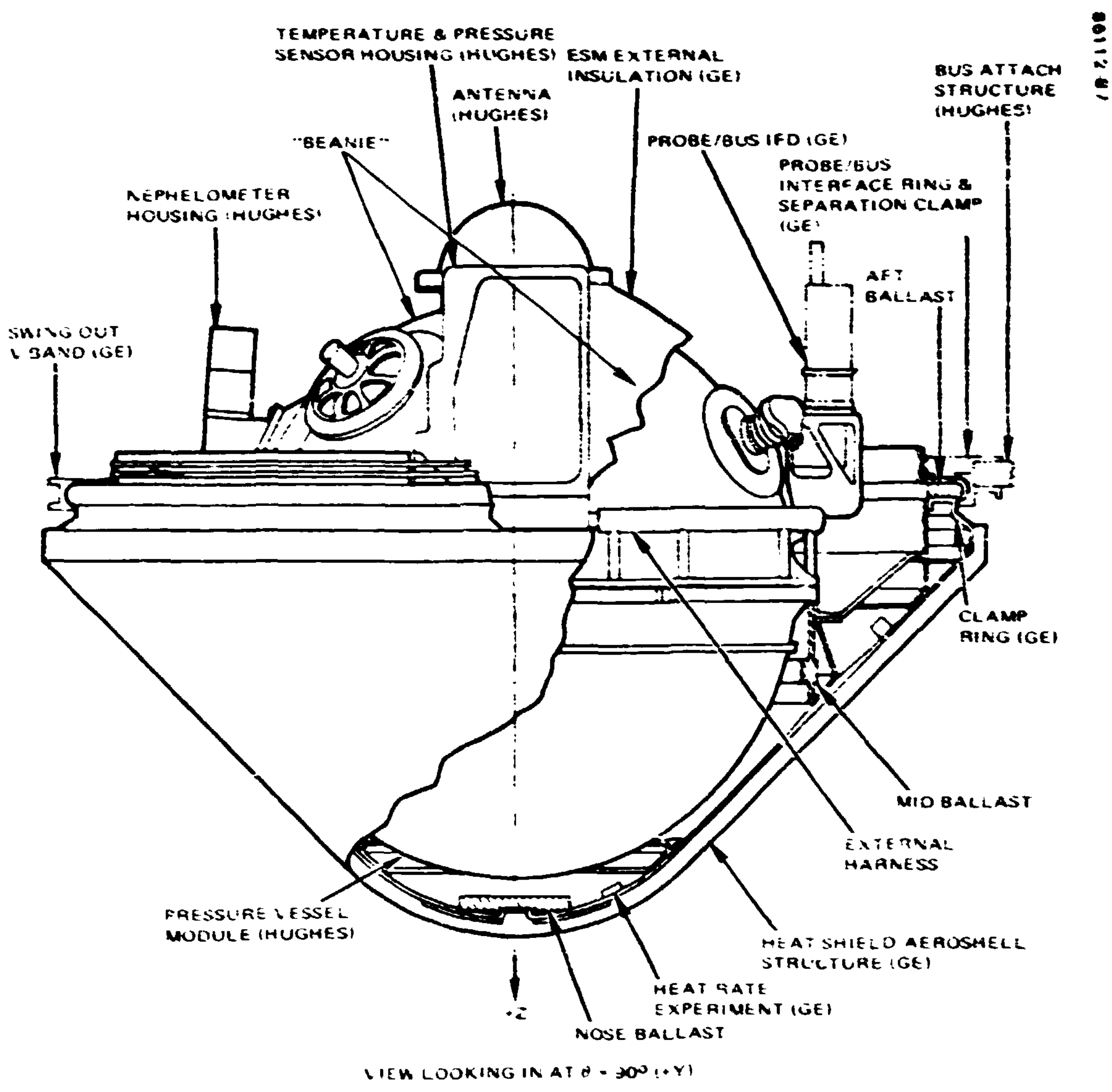

FIGURE 5.2.1-3 SMALL PROBE (SIDE VIEW)

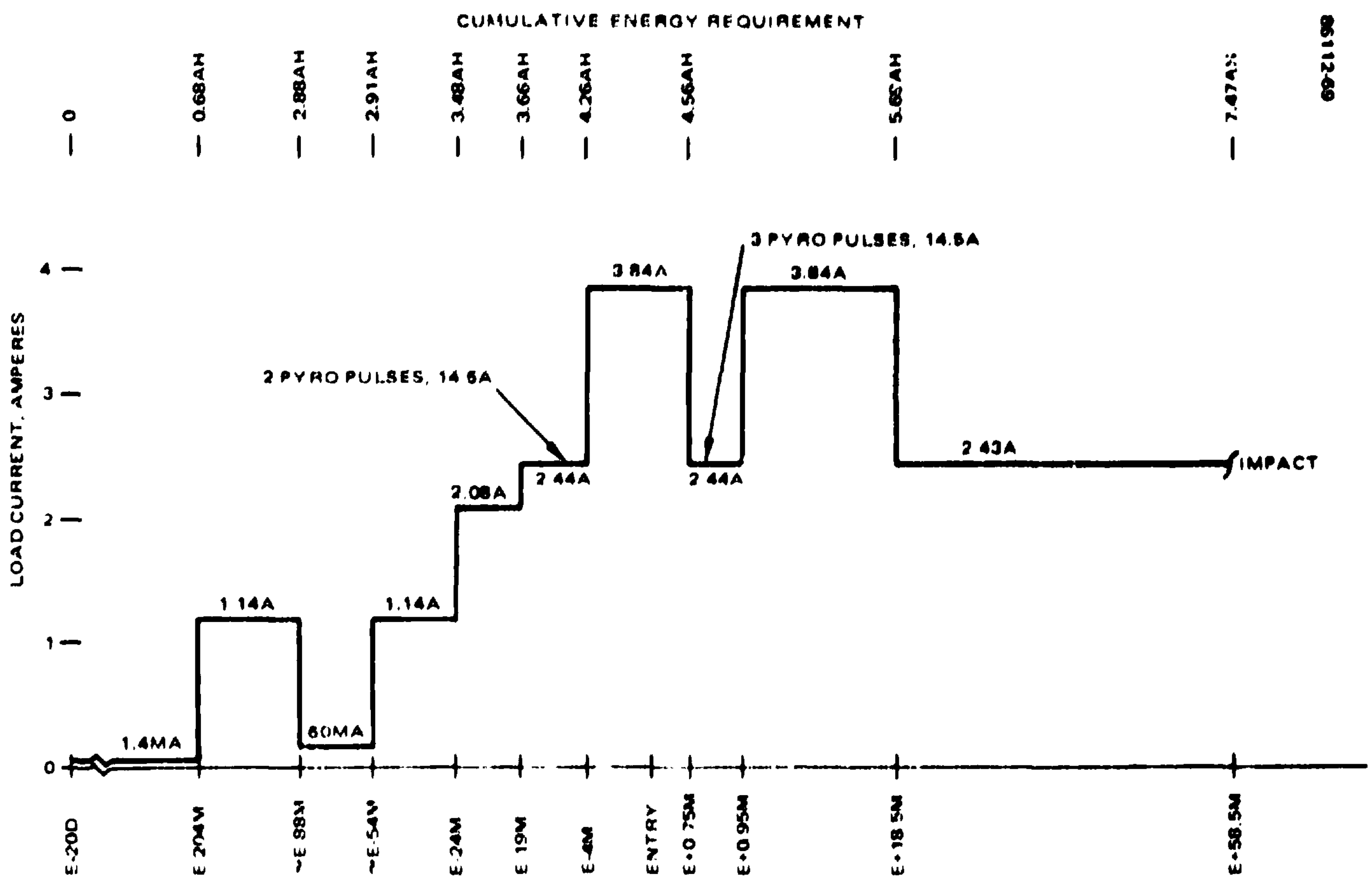

FIGURE 5.2.1 4. SMALL PROBE BATTERY CURRENT/ENERGY REQUIREMENTS VERSUS MISSION TIME

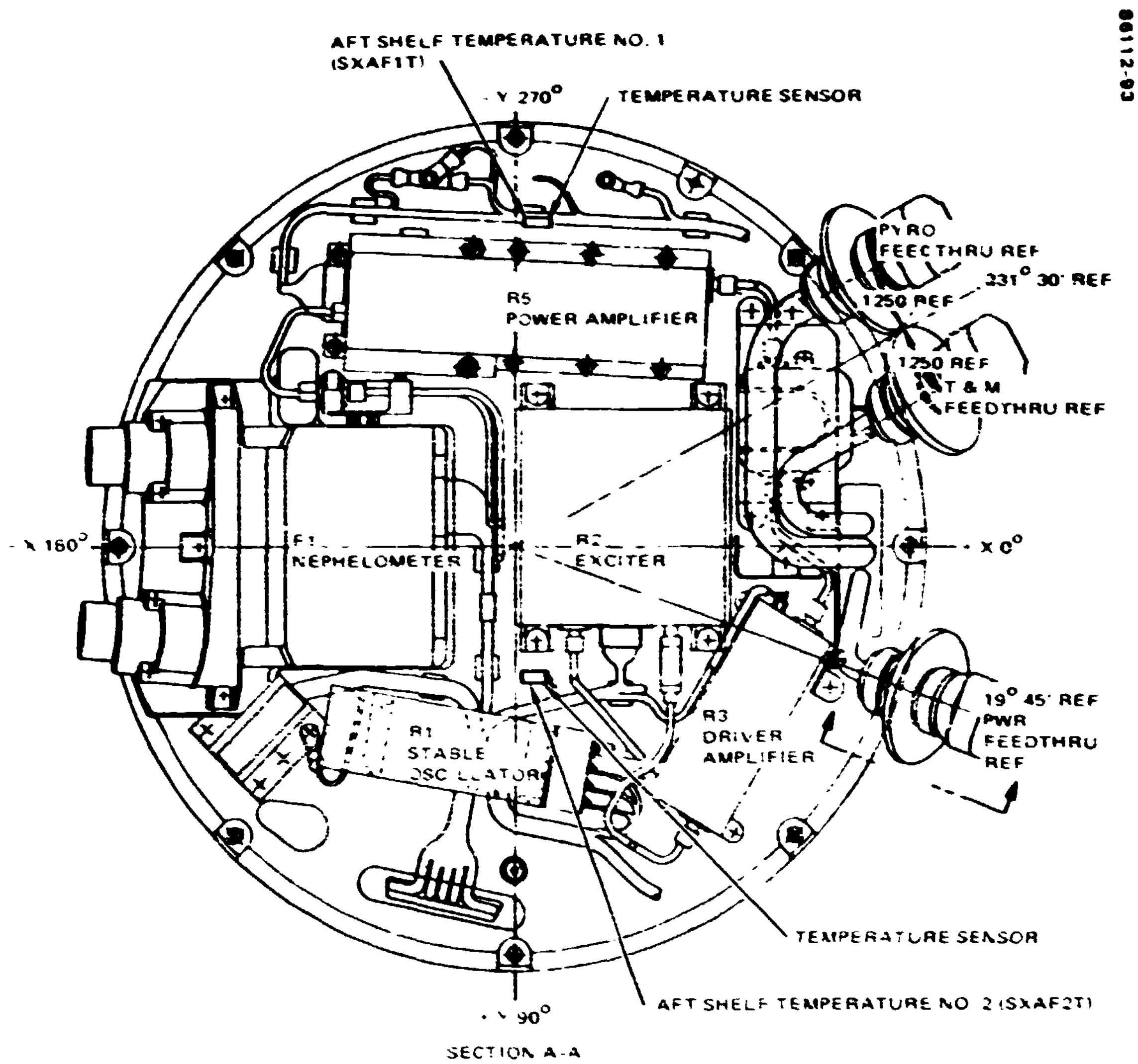

FIGURE 5.2.1-5 SMALL PROBE AFT SIDE, AFT SHELF

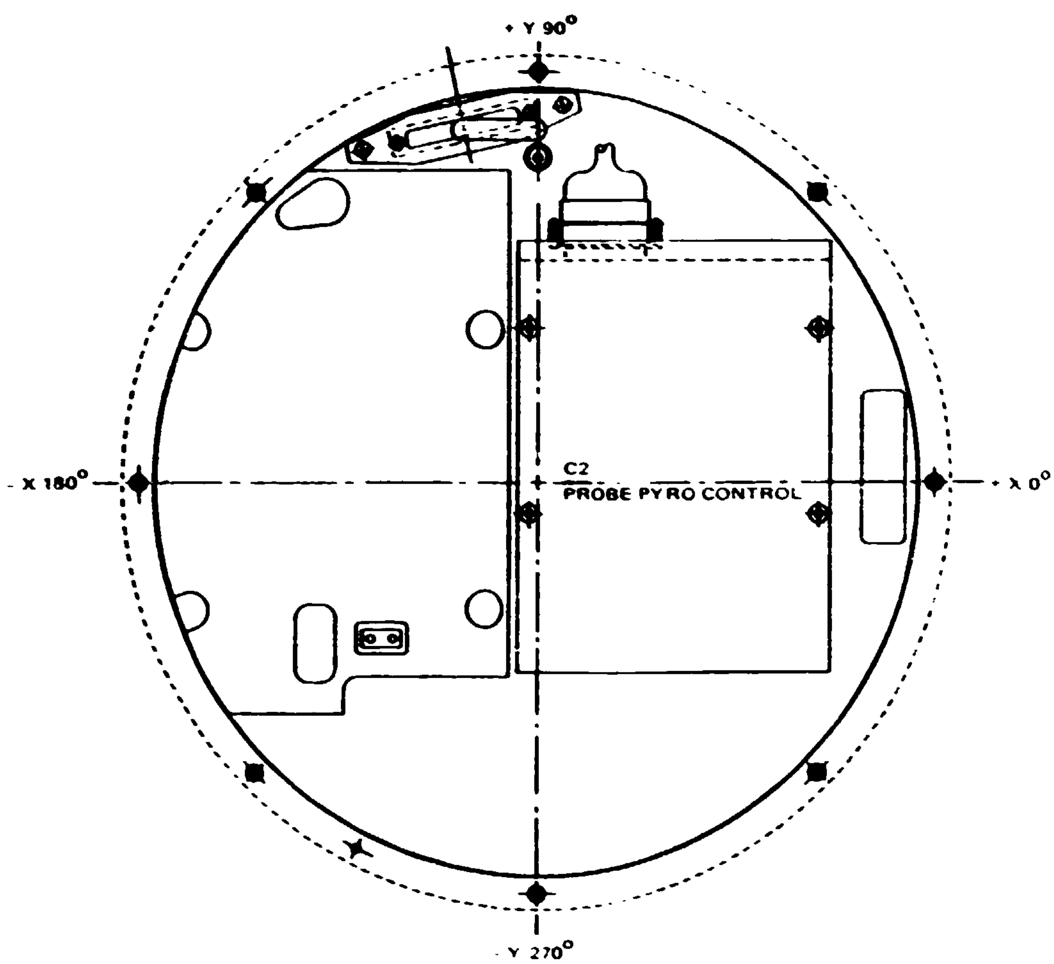

FIGURE 5.2.1-6 SMALL PROBE FORWARD SIDE, AFT SHELF

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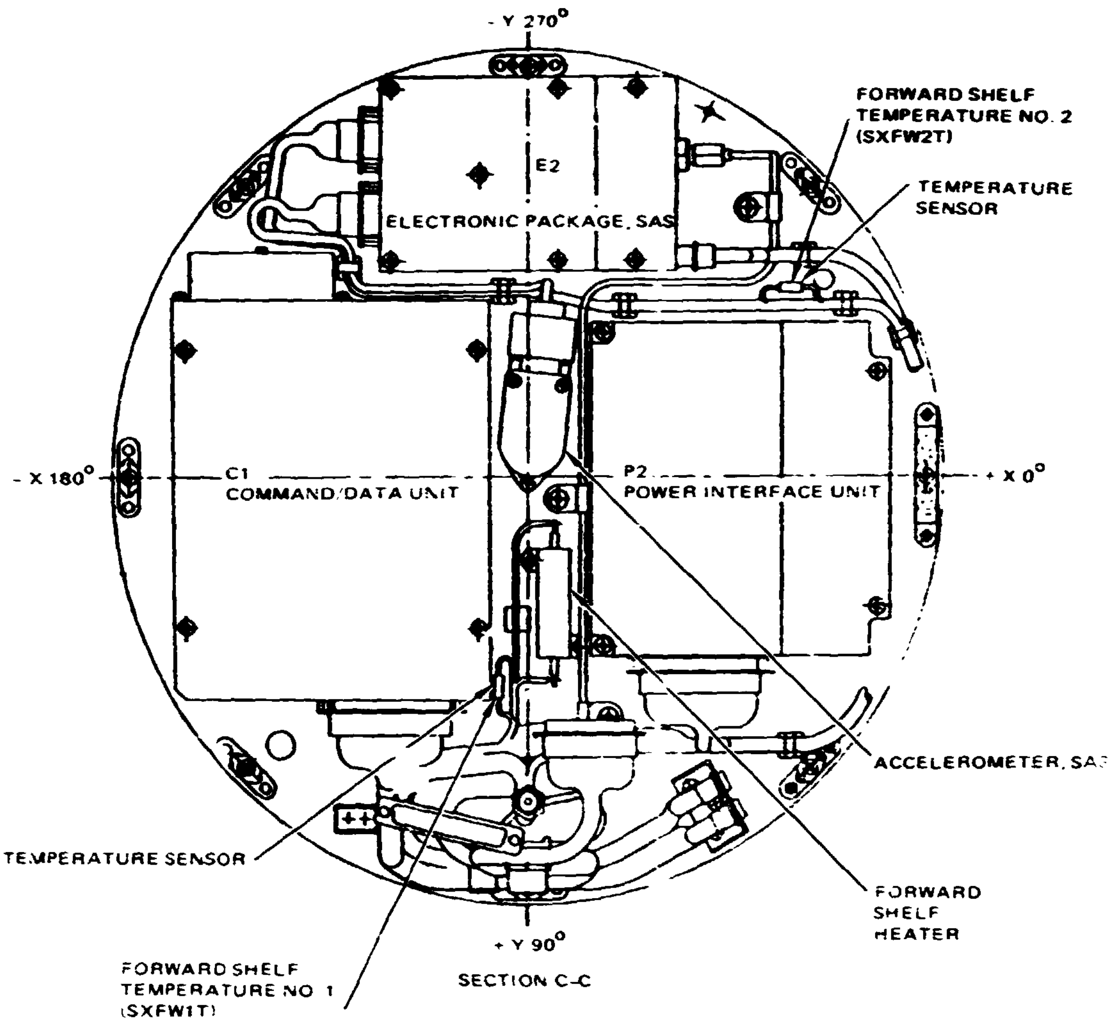

FIGURE 5.2.1-7 SMALL PROBE AFT SIDE, FORWARD SHELF

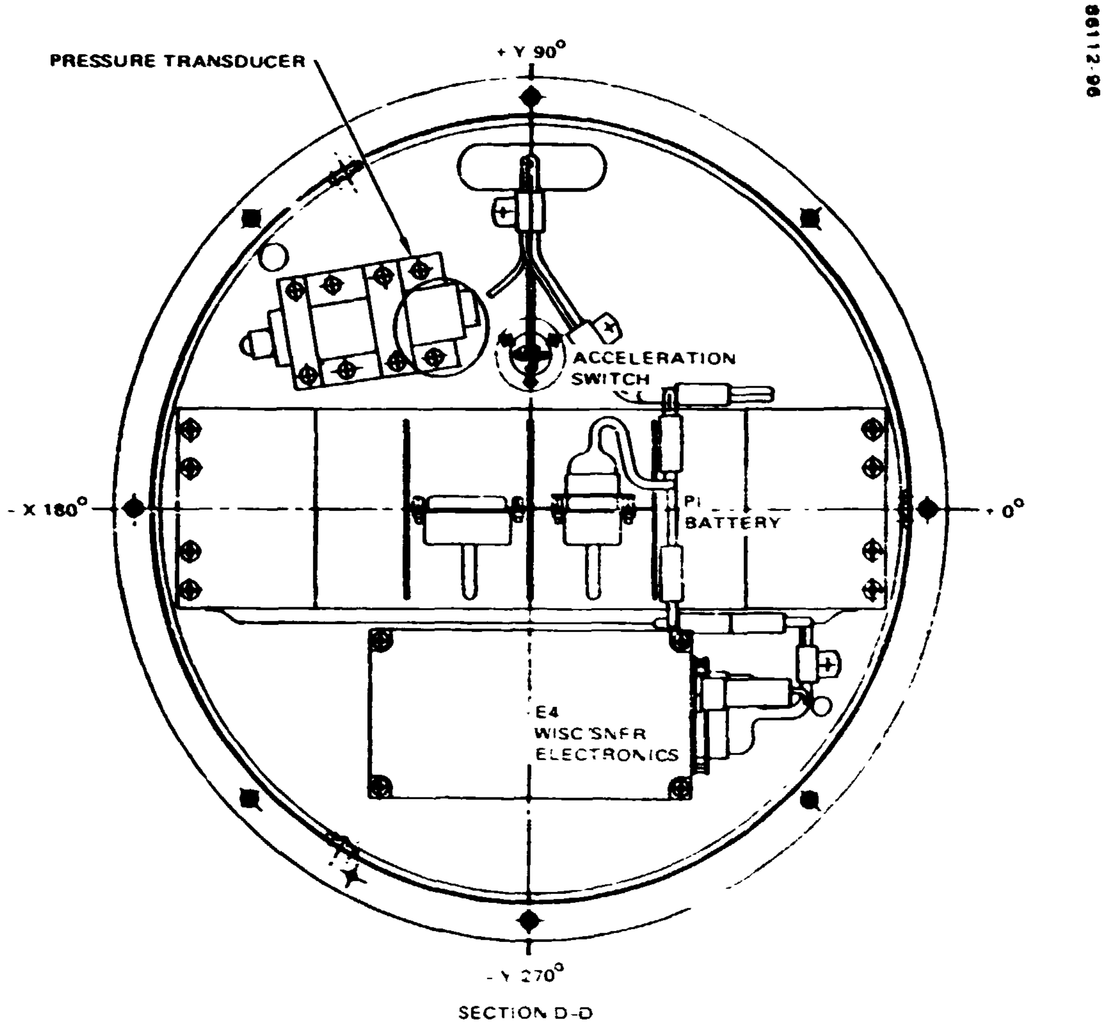

FIGURE 5.2.1-8 SMALL PROBE FORWARD SIDE, FORWARD SHELF

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****                                ****
****   This Figure is a Foldout.    ****
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****        See APPENDIX C          ****
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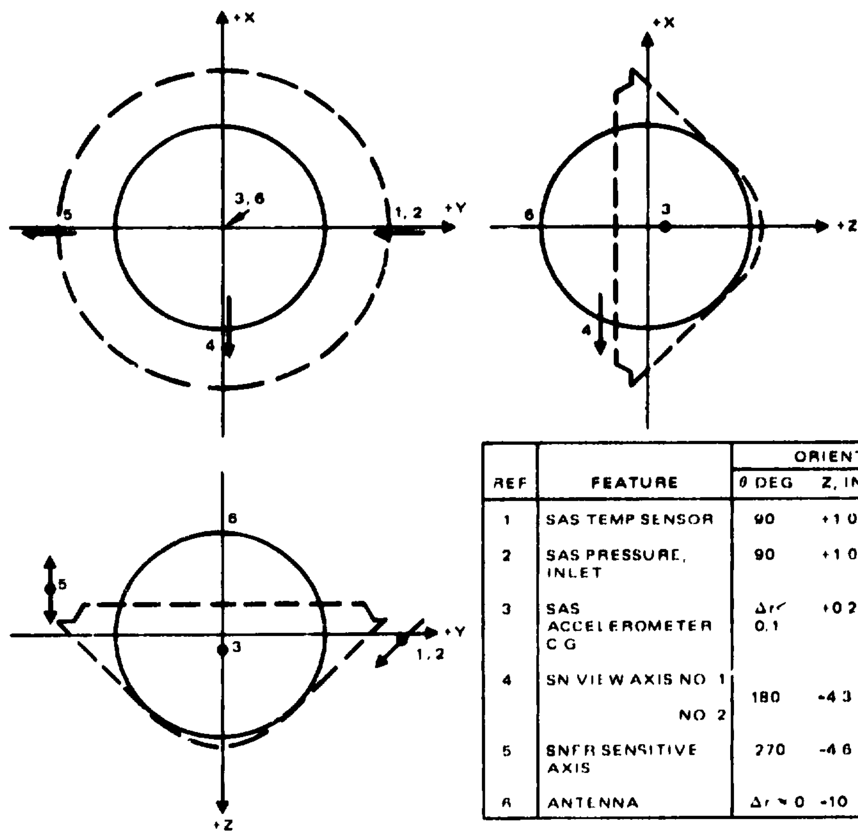
Figure 5.2.2.2-1



REF	FEATURE	ORIENTATION			FIELD OF VIEW		DETAILED DRAWING REFERENCE
		θ DEG	Z, IN	ϕ DEG	$\Delta\theta$ DEG	$\Delta\phi$ DEG	
1	SAS TEMP SENSOR	90	+1.0	135			3385067 400
2	SAS PRESSURE, INLET	90	+1.0	135			3385067 400
3	SAS ACCELEROMETER C G	$\Delta r <$ 0.1	+0.2				
4	SN VIEW AXIS NO 1 / NO 2	180	-4.3	0	$\pm$6 / $\pm$16	+7, 16	3385932 400
5	SNFR SENSITIVE AXIS	270	-4.6	90, 270 (1)			3385933-400
6	ANTENNA	$\Delta r \approx 0$	-10	270		$\pm$70	

DEFINITIONS

θ - AZIMUTH ORIENTATION MEASURED IN A POSITIVE SENSE ABOUT +Z AXIS FROM +X AXIS

ϕ - ELEVATION ORIENTATION MEASURED IN A POSITIVE SENSE ABOUT +X AXIS FROM +Y AXIS

Z - STATION MEASURED ALONG Z AXIS FROM 0.0 REFERENCE AT AFT FACE OF FORWARD HEMISPHERE MOUNTING INTERFACE FLANGE.

NOTES

1) SNFR SENSOR IS PERIODICALLY ROTATED 180° ABOUT -Y AXIS WITH VIEWING ALTERNATING BETWEEN θ = 90 DEG AND θ = 270 DEG

FIGURE 5.2.2.3.2-1. SMALL PROBE SCIENTIFIC INSTRUMENTS AND ANTENNA LOCATIONS AND FIELDS OF VIEW

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OF POOR QUALITY

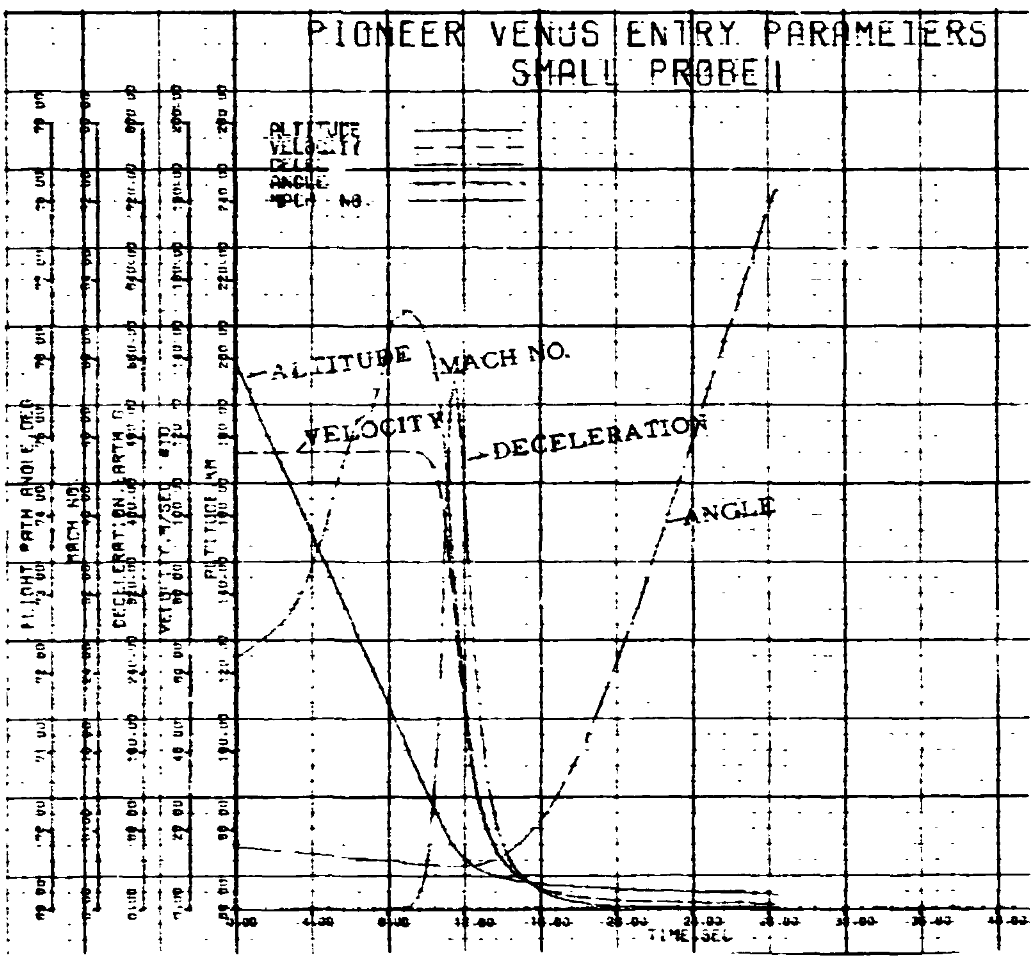

Figure 5.2.3-1. Small Probe 1 Entry Trajectory Parameters

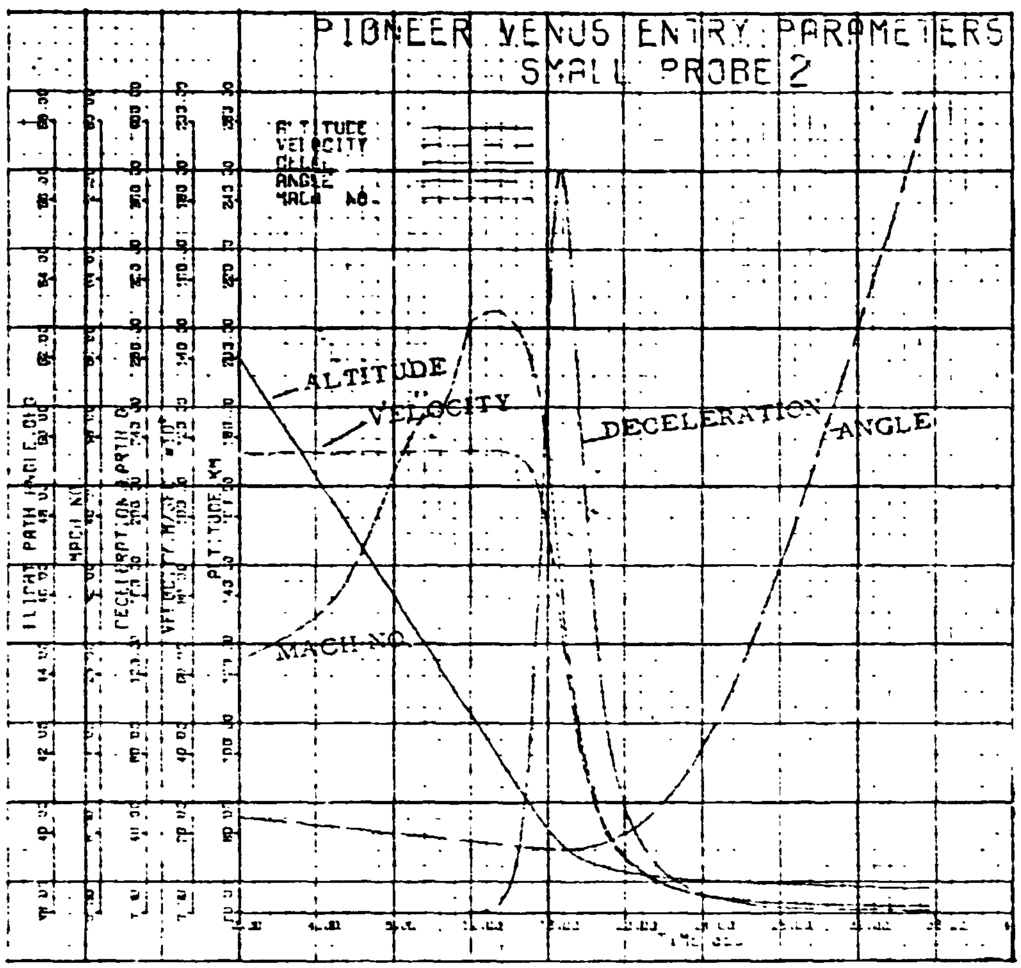

Figure 5.2.3-2. Small Probe 2 Entry Trajectory Parameters

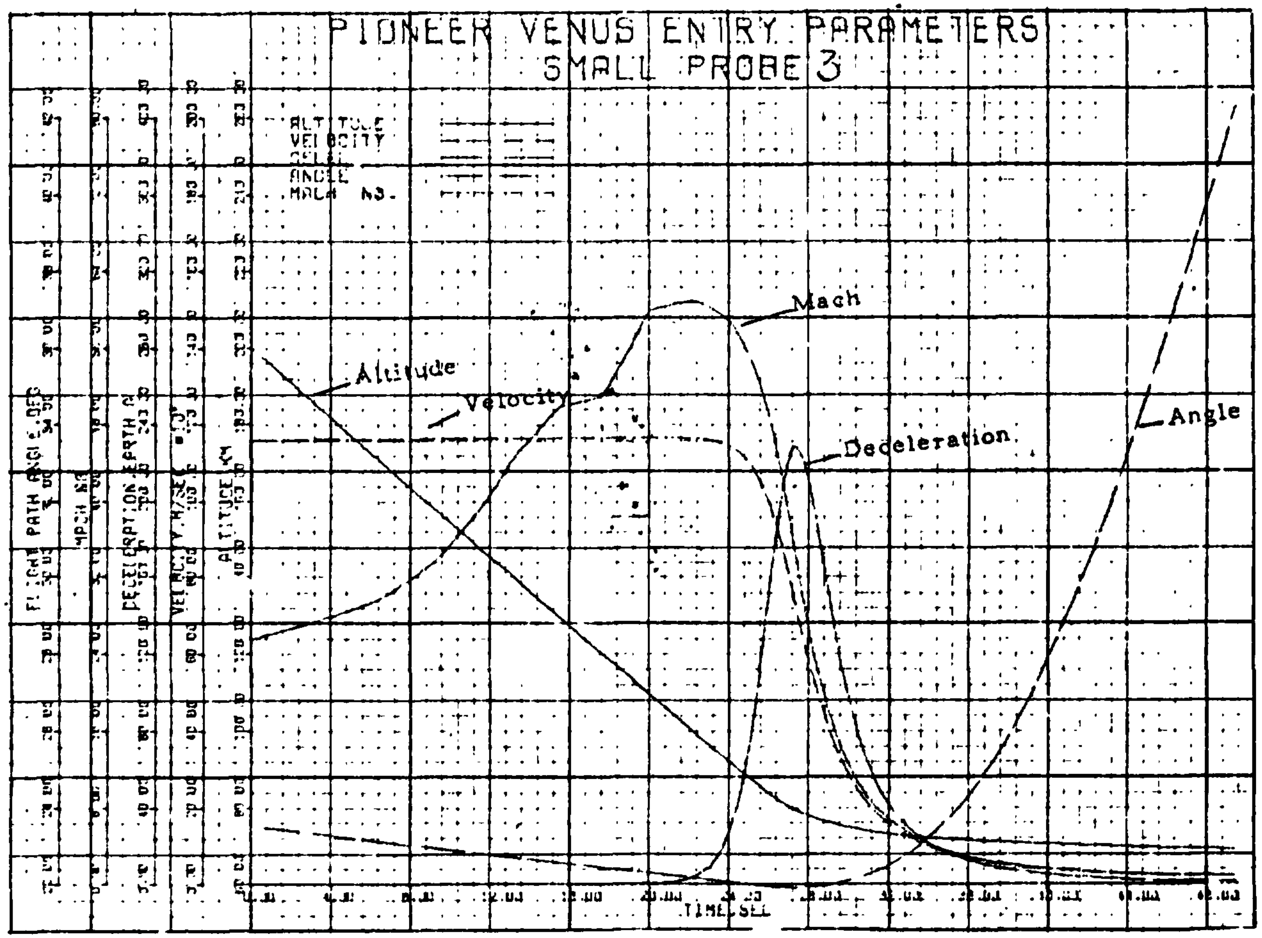

Figure 5.2.3-3. Small Probe 3 Entry Trajectory Parameters

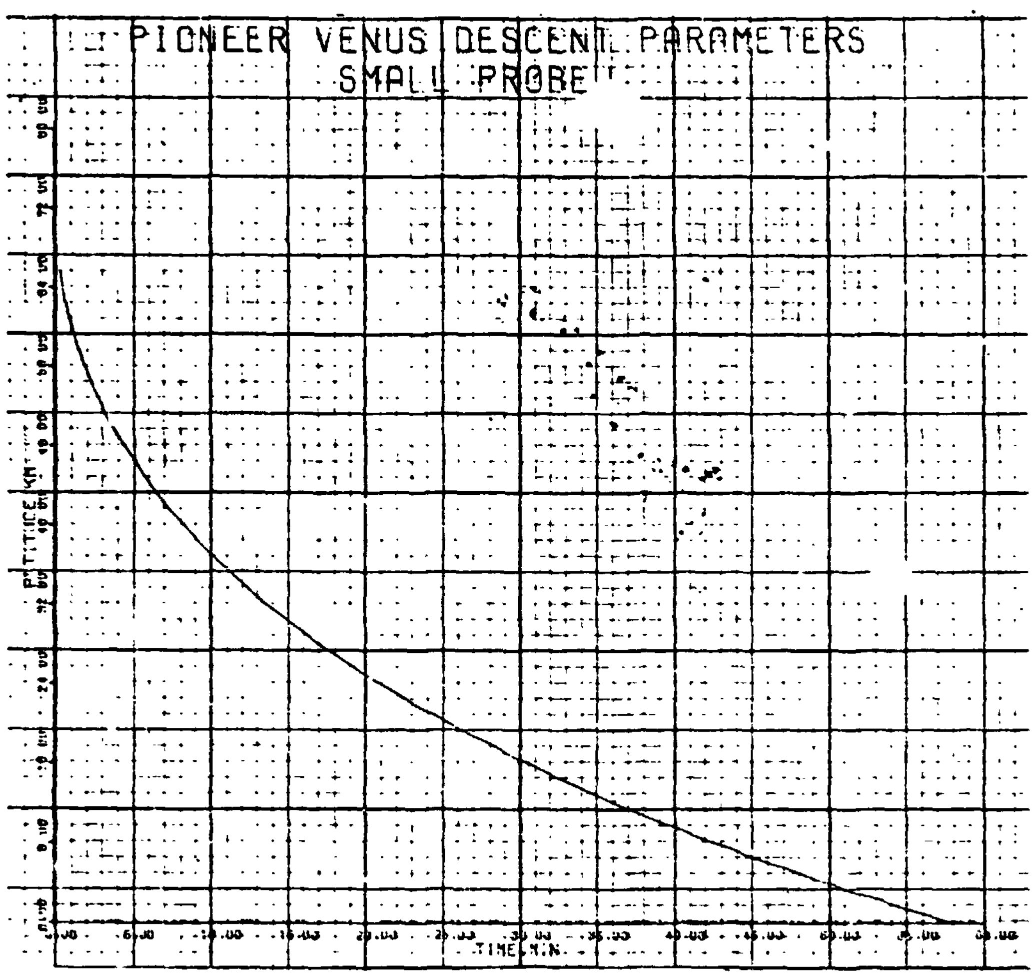

Figure 5.2.3-4. Small Probe 1 Altitude Versus Descent Time

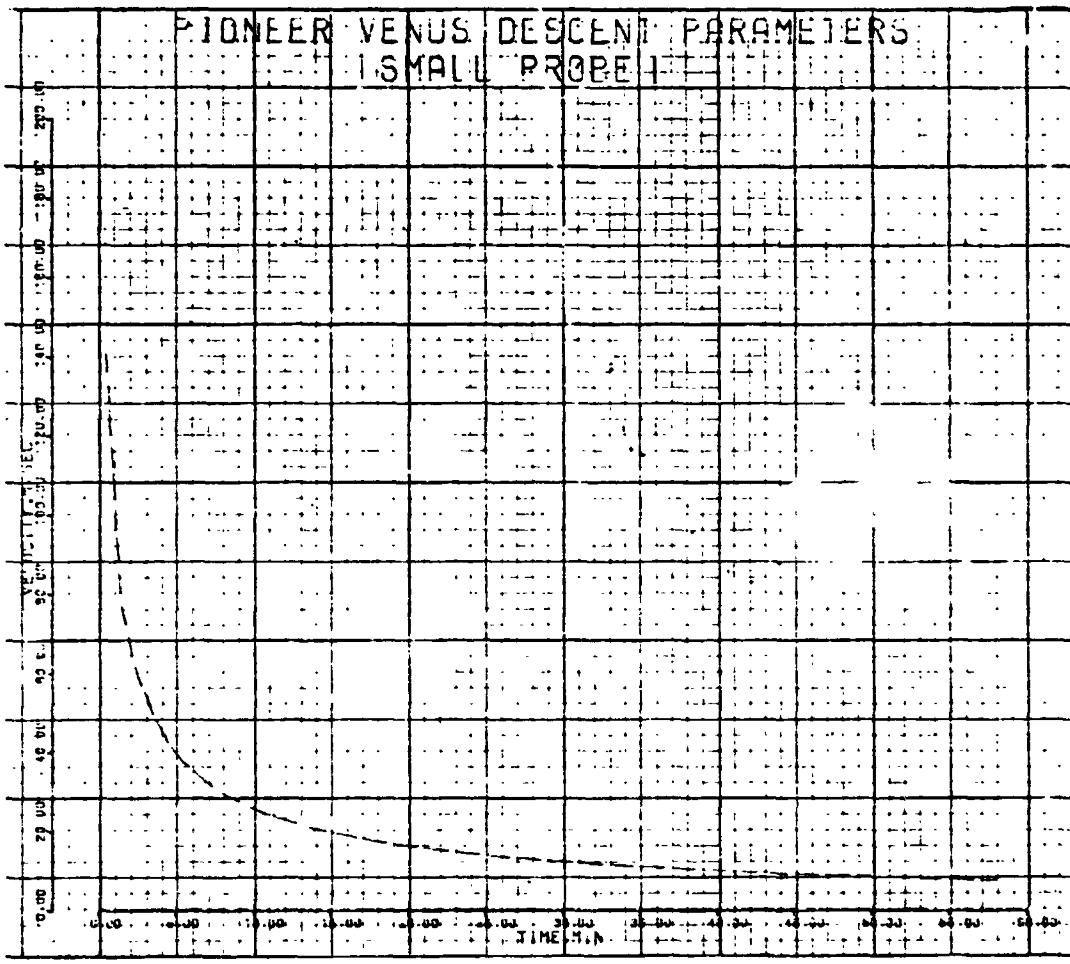

Figure 5.2.3-5. Small Probe 1 Velocity Versus Descent Time

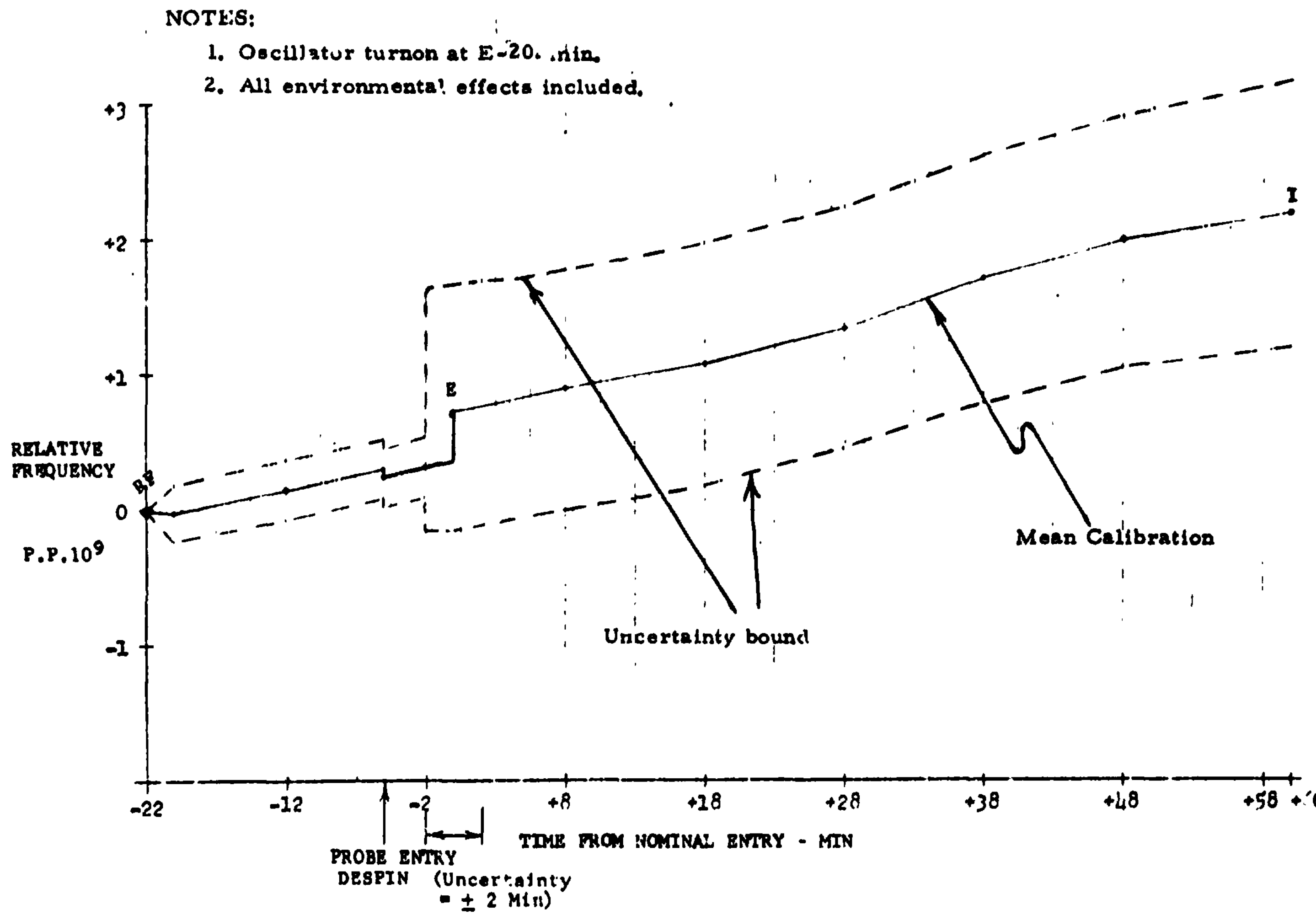

Figure 5.2.3.1-1. Stable Oscillator Frequency Calibration Small Probe 1 (SN003 Oscillator)

Section No. 5.2.3.2
P-C. No. PC-403
Orig. Issue Date 5/22/78
Revision No. ______ Revision

NOTES:

1. Oscillator turnon at E-202 min.
2. All environmental effects included.

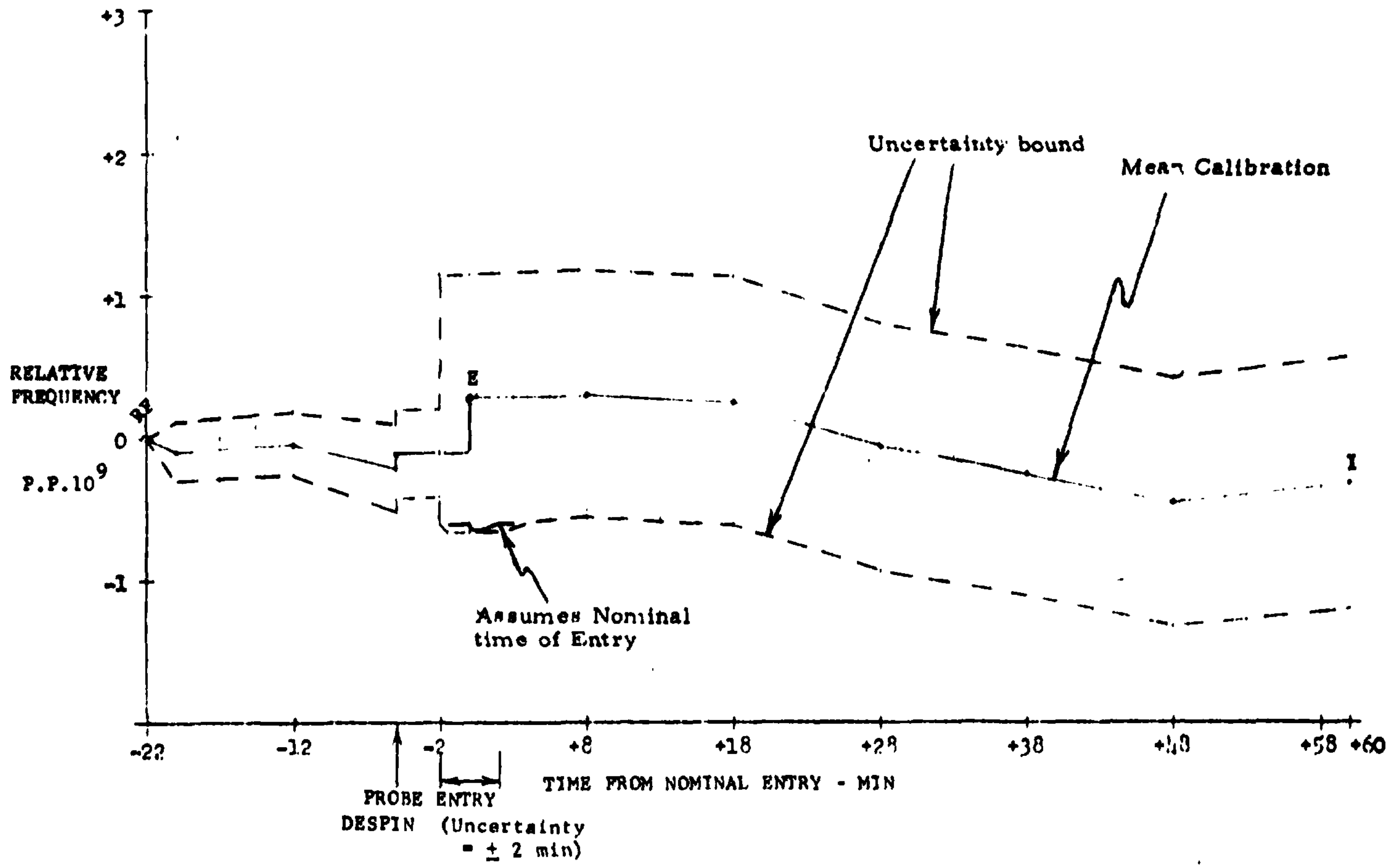

Figure 5.2.3.1-2. Stable Oscillator Frequency Calibration Small Probe 2 (SN002 Oscillator)

NOTES:

1. Oscillator turnon at E-202 min.
2. All environmental effects included.

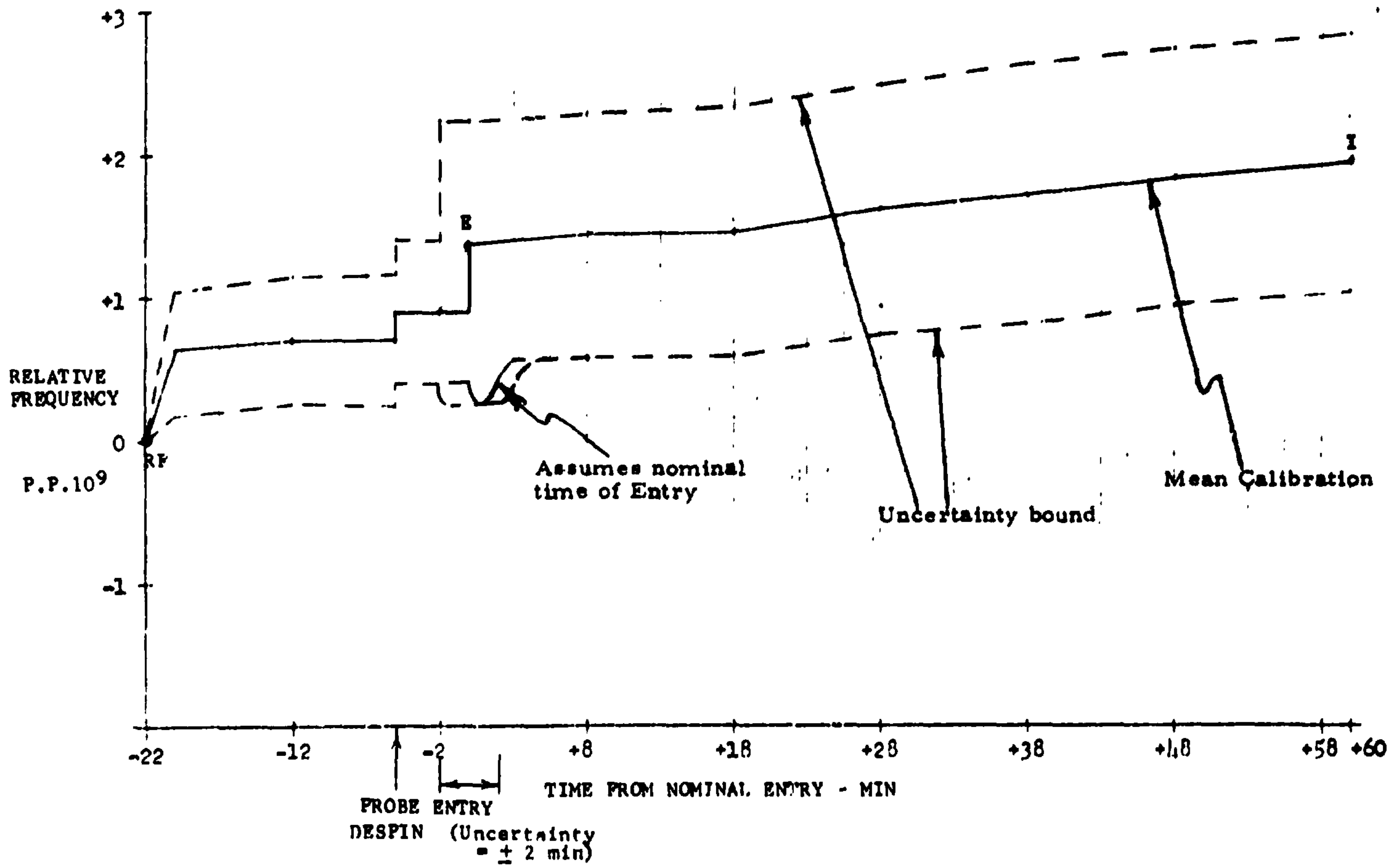

Figure 5.2.3.1-3. Stable Oscillator Frequency Calibration. Small Probe 3 (SN001 Oscillator)

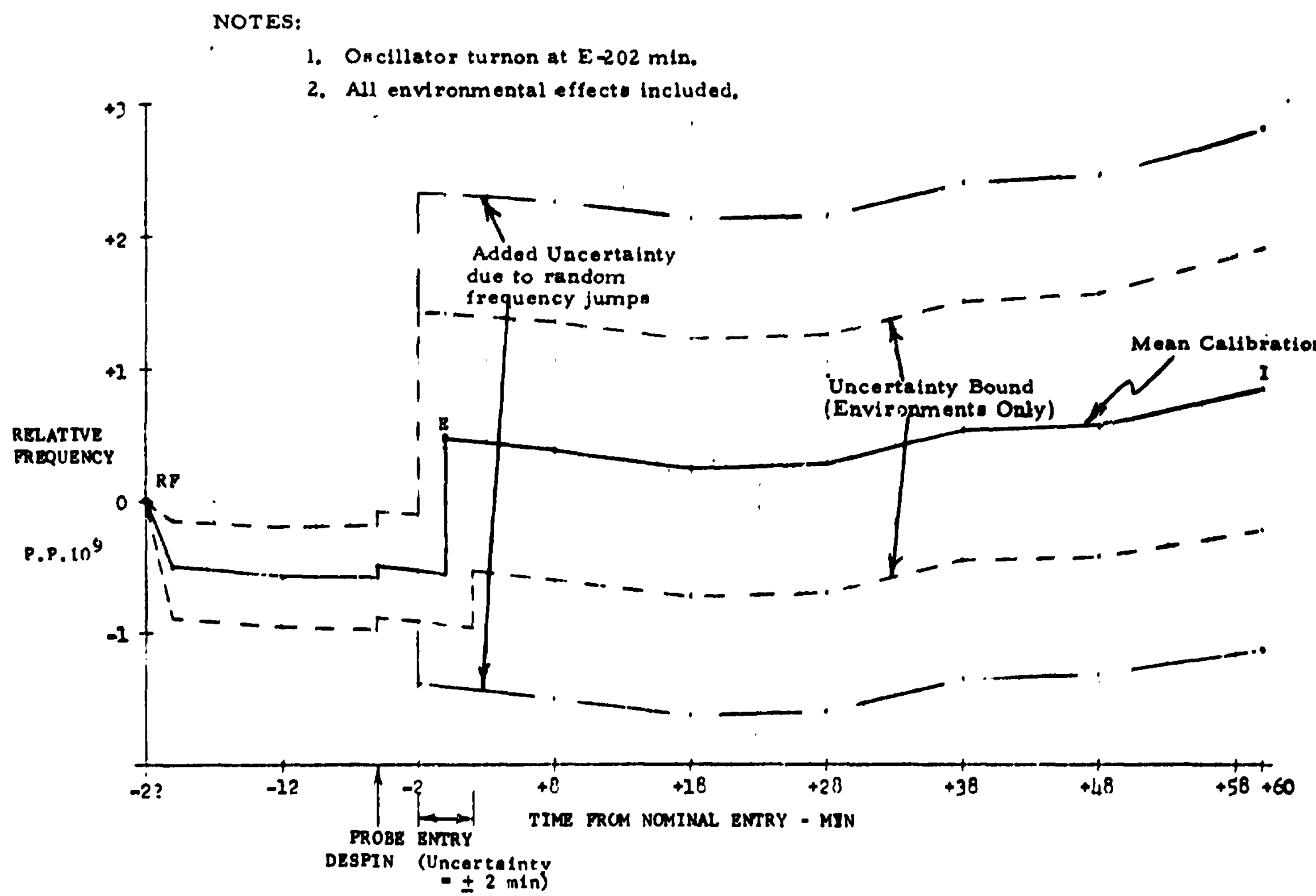

Figure 5.2.3.1-4. Stable Oscillator Frequency Calibration Spare Unit - SN004

APPENDIX A

TELEMETRY REFERENCE DATA

(BY SPACECRAFT SUBSYSTEM GROUPING)

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

'UBSYSTEM: (A. 1. 1) Bus Spacecraft Level

M MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
	Telemetry Format Selection	Overhead Word #3 - Digital (4 bits) (None)	16 Discrete levels - From 0000 to 1111 - representing any one of 16 selected formats.	Sw. loads bus to ECU in TP that is ON to +5V line.	Location 2 of RAM (scratch pad memory).
	Bit Rate Selection	Overhead Word #3 - Digital (4 bits) (bps)	16 Discrete levels - From 0000 to 1111 - representing any one of 13 selected bit rates. 0000 = 8 bps; 1100 or 1101 or 1110 or 1111 = 4096 bps.	Sw. loads bus to ECU in TP that is ON to +5V line.	Location 2 of RAM (scratch pad memory).
	Spacecraft ID	Overhead Word #4 - Digital (2 bits) (None)	00 = Bus 10 = Orbiter	Sw. loads bus to ECU in TP that is ON to +5V line.	Location 14 of RAM (scratch pad memory). Pin programming is sampled and stored in RAM.
DSCIDC	Minor Frame Count	Overhead Word #4 - Digital (6 bits) (Decimal)	000000 = Frame #0 . . . . . . 111111 = Frame #63	Sw. loads bus to ECU in TP that is ON to +5V line.	Location 14 of RAM (scratch pad memory).

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.1.2) Probe System Level

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
DXSTRS	Data Storage	Probe TM Format Overhead Word #3- Digital (Bit 0) (None)	1 = Storing 0 = Not Storing	+28V (Checkout pwr or internal pwr) to ECU to +5V line in CDU.	Data Storage Memory - Flip-flop output.
CXASWS	Acceleration Switch Status	Probe TM Format Overhead Word #3 (Bit 1) (None)	1 = switch actuated 0 = switch not actuated	"	Multiplexer logic - Inverter output.
CLTSWS	Thermal Switch Status (Large Probe only)	Probe TM Format Overhead Word #3 (Bit 2) (None)		"	Event Logic - Inverter Output.
	Probe ID	Probe TM Format Overhead Word #3 (Bits 3 & 4) (None)	11 = Large Probe 00 = Small Probe 1 01 = Small Probe 2 10 - Small Probe 3	"	Sync & ID Generator Logic: +5V to 10K Ohm. Derived from pin programming
	Format Status	Probe TM Format Overhead Word #3 (Bits 5&6) (None)	Binary Count: / For Small Probe: / For Large Probe: 00 / Upper Descent / Descent 11 / Blackout / Blackout 01 / Lower Descent / Spare	"	Format select Logic. Two parallel inverters to 5.1 K to +5V.
	Bit Rate Status	Probe TM Format Overhead Word #3 (Bit 7) (bps)	Binary Count: / For Small Probe: / For Large Probe: 1 / 64 bps / 256 bps 0 / 16 bps / 128 bps	"	Countdown & Bit Rate Select Logic - NAND Gate Output.

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APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A. 1. 2) Probe System Level

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
DMAJFC	Major Frame Count	Probe TM Format Overhead Word #4 (Bits 0 to 3) (Counts)	1111 = 15 Counts 0000 = 00 Counts	+28V (Checkout pwr or internal pwr) to ECU to +5V line in CDU.	Eight-bit shift register to 20K Ohm to +5V. (4 bits for Major Frame).
LBCIDC	Minor Frame Count	Probe TM Format Overhead Word #4 (Bits 4 to 7) (Counts)	1111 15 Counts 0000 0 Counts	"	Eight-bit shift to 20 K Ohm to +5V. (4 bits for Minor Frame).

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A. 2) Structure/Harness

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
SHLØ1T	Shelf Temperature 1	AC (°F)	69 Counts = -90°F 229 Counts = +196°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ2T	Shelf Temperature 2	AC (°F)	69 Counts = -85°F 226 Counts = +194°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ3T	Shelf Temperature 3	AC (°F)	69 Counts = -75°F 226 Counts = +204°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ4T	Shelf Temperature 4	AC (°F)	69 Counts = -75°F 226 Counts = +203°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ5T	Shelf Temperature 5	AC (°F)	69 Counts = -56°F 226 Counts = +222°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ6T	Shelf Temperature 6	AC (°F)	69 Counts = -68°F 226 Counts = +211°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ7T	Shelf Temperature 7	AC (°F)	69 Counts = -57°F 226 Counts = +220°F	Sw. loads bus to DIM 5 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ8T	Shelf Temperature 8	AC (°F)	69 Counts = -68°F 226 Counts = +211°F	Sw. loads bus to DIM 5 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHLØ9T	Shelf Temperature 9	AC (°F)	69 Counts = -85°F 226 Counts = +194°F	Sw. loads bus to DIM 5 & precision 1.0 milliamp output.	Thermistor, 908631-32.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.2) Structure/Harness

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
SHL1ØT	Shelf Temperature 10	AC (°F)	69 Counts = -60°F 226 Counts = +219°F	Sw. loads bus to DIM 7 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHL11T	Shelf Temperature 11	AC (°F)	69 Counts = -60°F 226 Counts = +219°F	Sw. loads bus to DIM 7 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SHL12T	Shelf Temperature	AC (°F)	69 Counts = -53°F 226 Counts = +226°F	Sw. loads bus to DIM 7 & precision 1.0 milliamp output.	Thermistor, 908631-32.
S1RELS	Small Probe 1 Stowed/Released Status	BL (None)	1 = Stowed 0 = Released	Sw. loads Bus to DIM 0 & precision 1.0 milliamp output.	
S2RELS	Small Probe 2 Stowed/Release Status	BL (None)	1 = Stowed 0 = Released	Sw. loads bus to DIM 0 & precision 1.0 milliamp output.	
S3RELS	Small Probe 3 Stowed/Released Status	BL (None)	1 = Stowed 0 = Released	Sw. loads bus to DIM 0 & precision 1.0 milliamp output.	
S1RELS	Large Probe Stowed/Released Status	BL (None)	1 = Stowed 0 = Released	Sw. loads bus to DIM 0 & precision 1.0 milliamp output.	
SBNMST	Bus Neutral Mass Spectrometer (BNMS) Temperature	AC (°F)	69 Counts = -54°F 226 Counts = +224°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908631-32.
SBIMST	Bus Ion Mass Spectrometer (BIMS) Temperature.	AC (°F)	69 Counts = -65°F 226 Counts = +213°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Thermistor, 908631-32.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
AADP1S	Attitude Data Processor 1 ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Sw. loads bus to (ADP 1 power conv. to +5V line).	Output of 5.1 K ohm resistor connected in series to +5V line in ADP 1. (Isolation Resistor)
AADP2S	Attitude Data Processor 2 ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Sw. loads bus to (ADP 2 power conv. to +5V line).	Output of 5.1 K ohm resistor connected in series to +5V line in ADP 2.
AJCE1S	Jet Control Electronics 1 Buffer Output Status	BL (None)	0 ≡ Disabled; 1 ≡ Enabled.	Sw. loads bus to (ADP 1 conv. to +15V line)	Resistor divider output from Q2A in microcircuit assembly DP2C in ADP 1.
AJCE2S	Jet Control Electronics 2 Buffer Output Status	BL (None)	0 ≡ Disabled; 1 ≡ Enabled.	Sw. loads bus to (ADP 2 conv. to +15V line).	Resistor divider output from Q2A in microcircuit assembly DP2C in ADP 2.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
A*1BRM	PSI* Brightness	AN (Volts)	0 Counts = 0 Volts } Linear 255 Counts = +5.10 Volts The equivalent silicon magnitude is related non-linearly to TM volts, via parameters of sensor temperature, bandpass state, S/C spin rate, and star elevation angle w.r.t. sensor boresight axis. Exact relationship is described in Ref: Par. 1.5.23.	Sw. loads bus to PSI* power converter to +15V, -15V and +9V lines.	PSI* Detector to peak detector.
A*1THS	PSI* Threshold Setting	AN (Star Magnitude)	0 Counts = 0 Volts } Linear 255 Counts = 5.1 Volts The eight threshold settings are: Threshold Setting / TM MILLIVOLTS (NOTE 1) / (NOTE 2) 8 / 314 / 300 7 / 376 / 380 6 / 456 / 460 5 / 556 / 560 4 / 903 / 900 3 / 1,448 / 1,440 2 / 2,307 / 2,300 1 / 3,651 / 3,640		PSI* Bandpass and Threshold Register. NOTE 1: From Ref. 1.5.23, given 1mv. telemetered resolution. NOTE 2: From HAC system tests, given 20 mv. telemetered resolution.
A*2BRM	PSI2* Brightness	AN (Volts)	Same as for A*1BRM.	Sw. loads bus to PSI2* Power conv. to +15V, -15V and +9V lines.	PSI2* Detector to variable Threshold Detector.
A*2THS	PSI2* Threshold Setting	AN (Star Magnitude)	0 Counts = 0 Volts } Linear 255 Counts = 5.1 Volts The eight threshold settings are: Threshold Setting / TM MILLIVOLTS (NOTE 1) / (NOTE 2) 8 / 215 / 220 7 / 274 / 260 6 / 345 / 340 5 / 436 / 440 4 / 750 / 740 3 / 1,242 / 1,240 2 / 2,023 / 2,020 1 / 3,243 / 3,240	Sw. loads bus to PSI2* power conv. to +15V, -15V and +9V lines.	PSI2* Bandpass and Threshold Register. NOTE 1: From Ref. 1.5.23, given 1mv. telemetered resolution. NOTE 2: From HAC Systems Tests, given 20mv. telemetered resolution.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
A*1ONS	PSI* ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Sw. loads Bus to PSI* Power Conv.	
A*2ONS	PSI2* ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Sw. loads bus to PSI2* Power Conv.	
ASTART	Star Sensor Temperature	AC (°F)	94 Counts = +8.9°F 147 Counts = +106.8°F	Sw. loads bus to DIM 7 and precision 1.0 milliamp output.	Thermistor, 90P631-32.
A*1BPS	PSI* Bandpass State Status	BL (None)	0 ≡ HI (19 Hz); 1 ≡ LO (2 Hz).	Sw. loads bus to PSI* Power conv. to +15V and -15V lines.	PSI* Bandpass and Threshold Register.
A*2BPS	PSI2* Bandpass State Status	BL (None)	0 ≡ HI (19 Hz); 1 ≡ LO (2 Hz).	Sw. loads bus to PSI2* power conv. to +15V and -15V lines.	PSI2* Bandpass and Threshold Register.
	ATTITUDE MEASUREMENT				
ATTM1Z	Attitude Measurement	SD (8 LSBs of 16 bit words). (Seconds)	0 TM Counts ≡ 0 Seconds; 65335 TM Counts ≡ 16.38 Seconds. (Resolution ≡ 0.25 msec).	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Output of 16 bit counter in micro-circuit assembly DP1M in ADP that is ON. Count start and stop controlled in turn by selection of azimuth time measurements (measurements A and B).
ATTM2Z	Attitude Measurement	SD (8 MSBs of 16 bit words). (Seconds)			

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
AM1ADS	Measurement A Address	SD (3 bits) (None)	6 Discrete levels - from 000 to 101 - representing any one of 6 azimuthal time measurements from SRR. (110=MIP on Orbiter; is excl. on Bus).	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage registers U15 and U16 (3 bits total) in microcircuit assembly DP1D in ADP that is ON.
AM2ADS	Measurement B Address	SD (3 bits) (None)	6 Discrete levels - from 000 to 101 - representing any one of 6 azimuthal time measurements from SRR. (110=MIP on Orbiter; is excluded on Bus).	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U16 (3 bits total) in microcircuit assembly DP1D in ADP that is ON.
ATTMSS	Data Measurement	SD (1 Bit) (None)	0 = Attitude Measurement applies for Measurement B; 1 = Attitude Measurement applies for Measurement A.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U14 in microcircuit assembly DP1H in ADP that is ON.
	ADP STATUS				
AJMAGC	JCE Countdown	SD (12 Bits) (Decimal pulse counts, if AMAGCS = 1;	0 to 4095 Pulse Counts.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Jet sequence converter in microcircuit assembly DP2B in ADP that is ON.
		Seconds if AMAGCS = 0.)	0 Counts = 0 Seconds; 4095 Counts = 2096.64 seconds.		
APULLS	Pulse Width Select.	SD (1 Bit) (Milliseconds of Pulse Width).	0 = 128 milliseconds pulse width selected; 1 = 512 milliseconds pulse width selected.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U23 in microcircuit assembly DP1E in ADP that is ON.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNEMONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
AMAGCS	Pulse/Time Count Select	SD (1 Bit) (None)	0 = Time Count selected for AJMAGC; 1 = Pulse Count selected for AJMAGC.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U23 in microcircuit assembly DP1E in ADP that is ON.
AJETMS (Word 2, Bit 6)	Continuous/Pulse Fire Select	SD (1 Bit) (None)	0 = Pulse Fire selected; 1 = Continuous Fires selected.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U23 in microcircuit assembly DP1E in ADP that is ON.
ASDETS	Spin Rate Detector	SD (1 Bit) (None)	0 = Inhibited; 1 = Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U23 in microcircuit assembly DP1E in ADP that is ON.
AJETMS (Word 3, Bit 0)	Normal/Alternate Fire Mode	SD (1 Bit) (None)	0 = Alternate fire selected; 1 Normal fire selected.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U22 in microcircuit assembly DP1E in ADP that is ON.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
	ADPSTATUS (Continued)				
AJET1S	Jet Select Bits	SD (7 Bits) (None)	Bit 1: 0 = Radial Jet 1 Disabled; 1 = Radial Jet 1 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U21 in microcircuit assembly DP1E in ADP that is ON.
AJET2S			Bit 2: 0 = Radial Jet 2 Disabled; 1 = Radial Jet 2 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U21 in microcircuit assembly DP1E in ADP that is ON.
AJET3S			Bit 3: 0 = Radial Jet 3 Disabled; 1 = Radial Jet 3 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U21 in microcircuit assembly DP1E in ADP that is ON.
AJET4S			Bit 4: 0 = Radial Jet 4 Disabled; 1 = Radial Jet 4 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U21 in microcircuit assembly DP1E in ADP that is ON.
AJET5S			Bit 5: 0 = Axial Jet 5 Disabled; 1 = Axial Jet 5 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U22 in microcircuit assembly DP1E in ADP that is ON.
AJET6S			Bit 6: 0 = Axial Jet 6 Disabled; 1 = Axial Jet 6 Enabled.	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U22 in microcircuit assembly DP1E in ADP that is ON.
AJET7S	NOTE: Bit 7 is selectable by command, but does not control any jet on the Bus.		Bit 7: 0 = Axial Jet 7 Disabled; 1 = Axial Jet 7 Enabled. } For Orbiter	Sw. loads bus to ADP that is ON to its converter and to +5V line.	Storage register U22 in microcircuit assembly DP1E in ADP that is ON.

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
	ADP STATUS (Continued)				
AJCEFS	JCE Fire Enable Status	SD (1 Bit) (None)	0 = Disabled; 1 = Enabled.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Main gate U13D in microcircuit assembly D8PB in ADP that is ON.
A*GASS	Star Gate A; Channel 1/2 Select	SD (1 Bit) (None)	0 = Channel 2 (ψ*2) Selected; 1 = Channel 1 (ψ *) Selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U21 in microcircuit assembly DP1F in ADP that is ON.
A*GBSS	Star Gate B; Channel 1/2 Select	SD (1 Bit) (None)	0 = Channel 2 (ψ*2) Selected. 1 = Channel 1 (ψ*) Selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U22 in microcircuit assembly DP1F in ADP that is ON.
ASUNSS	Sun Sensor Select	SD (2 Bits) (None)	3 Discrete levels - from 00 to 10 - representing any one of three sun sensor ranges selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U22 (2 bits total) in microcircuit assembly DP1F in ADP that is ON.
ASRRMS	Sun/Star Select; Simulated SRR Select	SD (2 Bits) (None)	Bit 5: 0 = Star Selected; 1 = Sun Selected. Bit 6: 0 = Simulated SRR Selected; 1 = SRR Selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U22 & U23 (2 bits total) in microcircuit assembly DP1F in ADP that is ON.
A*ACQS	Star Acquisition/ Normal	SD (1 Bit) (None)	0 = Normal Selected; 1 = Star Acquisition Selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U23 in microcircuit assembly DP1F in ADP that is ON.
ASPINS	PLL Spin Range Select	SD (2 Bits) (RPM)	4 Discrete levels - from 00 to 11 - representing any one of four spin ranges selected.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U21 (2 bits total) in microcircuit assembly DP1F in ADP that is ON.
ALOLES	PLL Loss of Lock Enable/ Inhibit	SD (1 Bit) (None)	0 = Disabled; 1 = Enabled.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U21 in microcircuit assembly DP1F in ADP that is ON.
ASUNGS	Enable/Disable Sun Gate	SD (1 Bit) (None)	0 = Disabled; 1 = Enabled.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U23 in microcircuit assembly DP1F in ADP that is ON.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.3) Control

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
	ADP STATUS (Continued)				
ADVANS	SRR Advance Status	SD (1 Bit) (None)	0 = Not Advanced; 1 = Advanced.	Sw. loads bus to ADP that is ON to its converter to +5V line.	Storage register U23 in microcircuit assembly DP1F in ADP that is ON.
APRELS	Small Probe Release Pulse Status	SD(1 Bit) (None)	0 = Probe Release pulse not generated; 1 = Probe Release pulse generated.	Sw. loads bus to ADP that is ON to its converter to +5V line.	J-K FLIP-FLOP U28A in microcircuit assembly DP4L in ADP that is ON.
ARIPAD	Roll Index Delay Magnitude	SD (10 Bits) (Angular degrees in Azimuth)	0 TM Counts = 0 Degrees; 1024 TM Counts = 359.65 Degrees. Resolution = 0.351 Degrees.	Sw. loads bus to ADP that is ON to its converter to +5V line.	Storage registers U24, U25 & U26 (10 bits total) in microcircuit assembly DP1F in ADP that is ON.
ALOCKS	PLL Loss of Lock	SD (1 Bit) (None)	0 = Loss of Lock; 1 = No Loss of Lock.	Sw. loads bus to ADP that is ON to its converter & to +5V line.	Storage register U21 in microcircuit assembly DP1F in ADP that is ON.
AMISSC	Missed SRR Count (0-8) Counts	SD (4 Bits) (Decimal Counts)	9 Discrete levels from 0000 to 1000 - representing number of successive out-of-PLL-Lock SRR pulses.	Sw. loads bus to ADP that is ON to its converter to +5V line.	Storage register U21 in microcircuit assembly DP4K in ADP that is ON. Counter is a 4-bit counter; 3 bits are used for the count & the 4th bit is an overflow bit.
AACSAD	ACL Angle Delay Magnitude	SD (10 Bits) (Angular degrees in Azimuth)	0 TM Counts = 0.352 Degrees; 1024 TM Counts = 360.00 Degrees. Resolution = 0.352 Degrees.	Sw. loads bus to ADP that is ON to its converter to +5V line.	Storage registers U24, U25 & U26 (10 bits total) in microcircuit assembly DP1E in ADP that is ON.
ASIMSZ	PLL Spin Period Magnitude	SD (16 Bits) (Seconds)	0 TM Counts = 0 Seconds; 65535 TM Counts = 16.384 Seconds. Resolution = 0.25 milliseconds.	Sw. loads bus to ADP that is ON to its converter to +5V line.	Storage registers U17, U18, U19 & U20 (16 bits total) in microcircuit assembly DP1D in ADP that is ON.

SUBSYSTEM: (A.4) Propulsion

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
VJET6T	Aft Axial Jet 6 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908683-4.
VLIN1T	Propellant Line Temperature 1	AC (°F)	99 Counts = +17.9°F 221 Counts = +163.1°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.
VLIN2T	Propellant Line Temperature 2	AC (°F)	96 Counts = +17.9°F 214 Counts = +163.1°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.
VLIN3T	Propellant Line Temperature 3	AC (°F)	96 Counts = +17.9°F 211 Counts = +163.1°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908631-32.
VLIN4T	Propellant Line Temperature 4	AC (°F)	99 Counts = +17.9°F 220 Counts = +163.1°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908631-32.
VTANKP	Tank Pressure	AC (PSIA)	0 Counts = 0 PSIA 231 Counts = 383.5 PSIA	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Potentiometer type transducer.
VTNK1T	Tank 1 Temperature	AC (°F)	101 Counts = +17.9°F 225 Counts = +163.1°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908631-32.
VTNK2T	Tank 2 Temperature	AC (°F)	90 Counts = +17.9°F 202 Counts = +163.1°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.4) Propulsion

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
VJ12HS	R1 and R2 Line Heater Status	AN (Amps)	0 Counts = 0 Amps 50 Counts = 0.294 Amps Htr "ON" (nominal) = 52 ma @ 28V Htr "OFF" (failure) = 0 ma @ 28V	Essential bus down-stream of fuses.	Resistive divider, between negative terminal of R1 and R2 line heaters, and power ground.
VJ34HS	R3 and R4 Line Heater Status	AN (Amps)	Htr "ON" (nominal) = 52 ma @ 28V Htr "OFF" (failure) = 0 ma @ 28V	Essential bus, down-stream of fuses.	Resistive divider, between negative terminals of R3 and R4 line heaters and power ground.
VLVPHS	Latch Valve Primary Heater Status	AN (Amps)	0 Counts = 0 Amps 50 Counts = 0.061 Amps Htr "ON" (nominal) = 48 ma @ 28V Htr "OFF" (failure) @ 28V	Essential bus, down-stream of Primary/Secondary Propulsion Tank heater select relay terminal (primary line) and power ground.	Resistive divider, between negative terminals of Latch Valve 1 heater, Latch Valve 2 heater, F&D #1 line heater, F&D #2 line heater - all tied together - and power ground.
VFDVHS	Fill and Drain Valve Primary Heater Status	AN (Amps)	0 Counts = 0 Amps 50 Counts = 0.125 Amps Htr "ON" (nominal) = 74 ma @ 28V Htr "OFF" (failure) <55 ma @ 28V	Essential bus, down-stream of Primary/Secondary Propulsion Tank heater select relay terminal (primary line) and power ground.	Resistive divider, between negative terminals of F&D Valve #1 heater, F&D Valve #2 heater, F&D Valve #3 heater, F&D #3 Gas line - all tied together - and power ground.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (/ 4) Propulsion

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
VALV1S	Latch Valve 1 OPEN/CLOSED	BL (None)	0 = Closed; 1 = Open.	Sw. loads bus to DIM 2 & precision 1.0 milliamp output.	State of SPDT switch operated by Latch Valve 1 mechanism. Switch is grounded for "valve closed" state; open for "valve open" state.
VALV2S	Latch Valve 2 OPEN/CLOSED	BL (None)	0 = Closed; 1 = Open.	Sw. loads bus to DIM 2 & precision 1.0 milliamp output.	State of SPDT switch operated by Latch Valve 2 mechanism. Switch is grounded for "valve closed" state; open for "valve open" state.
VJET1T	Radial Jet 1 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908683-4.
VJET2T	Radial Jet 2 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908683-4.
VJET3T	Radial Jet 3 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908683-4.
VJET4T	Radial Jet 4 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908683-4.
VJET5T	Forward Axial Jet 5 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908683-4.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.5) Data Handling

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
DCLOK1	Spacecraft Clock (8 MSB)	SD (24 Bits) (Seconds)	0 TM Counts = 0 Seconds. $(2^{24} - 1)$ TM Counts = 2,097,151 Seconds (= 24.27 Days). Resolution = 0.125 Seconds.	Sw. loads bus to ECU in TP that is ON to +5V line.	Location 10, 11, & 12 of RAM (scratch pad memory). Origin of RAM update is minor frame rate signal counted down from 1.048 MHz clock in TP that is ON.
DCLOK2	Spacecraft Clock (8 Middle Bits)				
DCLOK3	Spacecraft Clock (8 LSB)				
DPCM1S	PCM Encoder 1 ON/OFF	BL (None)	0 = OFF 1 = ON	Sw. loads bus to Power Supply in PCME1 to +5V line.	Output of 1.0 Kohm resistor connected in series to +5V line in PCME1.
DPCM2S	PCM Encoder 2 ON/OFF	BL (None)	0 = OFF 1 = ON	Sw. loads bus to Power Supply in PCME2 to +5V line.	Output of 1.0 Kohm resistor connected in series to +5V line in PCME2.
DPCM1V	PCM Encoder 1 Calibrate	AC (Volts)	0 Counts = 0.0 Volts 255 Counts = +5.100 Volts	Sw. loads bus to Power Supply in PCME1 to -15V line.	Precision 1 milliampere current source into 4.87 Kohm $\pm 0.2\%$ resistor.
DPCM2V	PCM Encoder 2 Calibrate	AC (Volts)	0 Counts = 0.0 Volts 255 Counts = +5.100 Volts	Sw. loads bus to Power Supply in PCME2 to -15V line.	Precision 1 milliampere current source into 4.87 Kohm $\pm 0.2\%$ resistor.
DTLM1S	Telemetry Processor 1 ON/OFF	BL (None)	0 = OFF 1 = ON	Sw. loads bus to ECU to +5V line in TP 1.	Output of 8.2 Kohm resistor connected in series to +5V line in TP 1.
DTLM2S	Telemetry Processor 2 ON/OFF	BL (None)	0 = OFF 1 = ON	Sw. loads bus to ECU to +5V line in TP 2.	Output of 8.2 Kohm resistor connected in series to +5V line in TP 2.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.6) Command

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TEI ERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
CMEM1	Command Memory 1 Readout	SD (128 x 24 Bits Maximum in 8-bit Segments)	Any Commands and Time Delays.	Essential bus to CP1 ECU to +5V and -12V lines.	Command Memory in CP1.
CREV.S	Command Processor 1 Receiver Reverse State	BL (None)	0 ≡ Reverse Commanded; 1 ≡ Normal Commanded.	Essential bus to CP1 ECU to +5V line.	Output of 1 Kohm resistor connected to gate in series that is pulled up by 7.5 Kohm resistor connected to +5V.
CPWR1S	Command Processor 1 Power Status	BL (None)	0 ≡ OFF; 1 ≡ ON.	Essential bus to CP1 ECU to +5V line.	Output of 10 Kohm resistor connected in series to +5V line in CP1.
CREJ2S	CP2 Command Reject	SD (1 Bit) (None)	0 ≡ Real Time Command is Accepted; 1 ≡ Real Time Command is Rejected.	Essential bus to CP2 ECU to +15V & +5V lines.	Parallel in-serial out 8 bit shift register (U6) in telemetry logic module of CP2.
CCMD2C	Command Processor 2 Real Time Command Status	SD (7 Bits) (Decimal Count)	0 TM Counts ≡ 0 Commands; 127 TM Counts ≡ 127 Commands. (Number of real-time commands verified & executed since last reset of command counter).		
CLOG2S	CP2 Stored Command Logic State	SD (4 Bits) (None)	16 Discrete levels - from 0000 to 1111 - representing any one of 16 operating states.	Essential bus to CP2 ECU to +15V and +5V lines.	Parallel in-serial out 8 bit shift register (U4) in telemetry logic module of CP2.
C[illegible]L2S	CP2 Stored Command Logic ON/OFF Status	SD (1 Bit) (None)	0 ≡ OFF; 1 ≡ ON.		
CDMD2S	CP2 Demod. Squelch Status	SD (1 Bit) (None)	0 ≡ Squelched; 1 ≡ Not Squelched. (i.e., signal is present).		

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.6) Command

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
CREJ1S	CP1 Command Reject	SD (1 Bit) (None)	0 = Real time command is accepted; 1 = Real time command is rejected.	Essential bus to CP1 ECU to +15V & +5V lines.	Parallel in-serial out 8 bit shift register (U6) in Telemetry Logic Module of CP1.
CCMD1C	Command Processor 1 Real Time Command Status	SD (7 Bits) (Decimal Count)	0 TM Counts = 0 Commands 127 TM Counts = 127 Commands. (Number of real-time commands verified & executed since last reset of command counter).		
CLOG1S	CP1 Stored Command Logic State	SD (4 Bits) (None)	16 Discrete levels - from 0000 to 1111 - representing any one of 16 operating states.	Essential bus to CP1 ECU to +15V & +5V lines.	Parallel in-serial out 8 bit shift register (U4) in Telemetry Logic Module of CP1.
CSCL1S	CP1 Stored Command Logic ON/OFF State	SD (1 Bit) (None)	0 = OFF; 1 = ON.		
CDMD1S	CP1 Demod. Squelch Status	SD (1 Bit) (None)	0 = Squelched; 1 = Not Squelched. (i.e., signal is present)		
RREV1C	CP1 MSB Bits of Receiver Reverse Timer	SD (2 Bits) (Hours)	00 = 0 Hours 01 = 9.1 Hours 10 = 18.2 Hours 11 = 27.3 Hours } Since Last Automatic Reversal.		
SSEP1S	CP1 Separation (Switch) Status	SD (1 Bit) (None)	0 = Not Separated; 1 = Separated.	Essential bus to 20V zener diode in CP1.	Wiper arm of one pole of DPDT switch (spacecraft/attach fitting separation switch #1).
CMEM1C	Command Memory 1 Address Pointer	SD (7 Bits) (Decimal)	0 TM Counts = First Command Memory Cell Location; 127 TM Counts = 128th Command Memory Cell Location.	Essential bus to CP1 ECU to +5V & -12V lines.	Parallel in-serial out 8 bit shift register in SCL 1 (includes SSEP1S).

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.6) Command

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RREV2C	CP2 MSB of Receiver Reverse Timer	SD (2 Bits) (Hours)	01 = 9.1 Hours; 10 = 18.2 Hours; 11 = 27.3 Hours } Since Last Automatic Reversal	Essential bus to CP2 ECU to +15V & +5V lines.	Parallel in-serial out 8 bit shift register (U4) in telemetry logic module of CP2.
SSEP2S	CP2 Separation Status	SD (1 Bit) (None)	0 ≡ Not Separated; 1 ≡ Separated.	Essential bus to 20V Zener diode in CP2.	Wiper arm of one pole of DPDT switch (spacecraft/attach fitting separation switch #2).
CMEM2C	Command Memory 2 Address Pointer	SD (7 Bits) (Decimal)	0 TM Counts ≡ First Command Memory Cell Location; 127 TM Counts ≡ 128th Command Memory Cell Location.	Essential bus to CP2 ECU to +5V & -12V lines.	Parallel in-serial out 8 bit shift register in SCL2 (includes SSEP2S).
CMEM2	Command Memory 2 Readout	SD (128 x 24 Bits Maximum in 8-bit Segments)	Any commands and time delays.	Essential bus to CP2 ECU to +5V & -12V lines.	Command Memory in CP 2.
CREV2S	Command Processor 2 Receiver Reverse State	BL (None)	0 ≡ Reverse Commanded; 1 ≡ Normal Commanded.	Essential bus to CP2 ECU to +5V line.	Output of 1 Kohm resistor connected to gate in series that is pulled up by 7.5 Kohm resistor that is connected to +5V.
CPWR2S	Command Processor 2 Power Status	BL (None)	0 ≡ OFF; 1 ≡ ON.	Essential bus to CP2 ECU to +5V line.	Output of 10 Kohm resistor connected in series to +5V line in CP2.
C1T1MC	Small Probe 1 Timer Verification	SD (16 Bits) (Seconds)	Coast Time in decimal seconds $= \left(\frac{\Delta to - 63}{32}\right)$ truncated to the nearest decimal integer. $\Delta$to is the desired coast duration in decimal seconds.	+28V (ckout pwr or internal pwr) to sw. regulator to +5V in CDU.	Playback of Coast Timer Set data from Coast Timer telemetry Verification Circuit.
C2T1MC	Small Probe 2 Timer Verification.	"	"	"	"

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.6) Command

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
C3TIMC	Small Probe 3 Timer Verification	SD (16 Bits) (Seconds)	Coast time in decimal seconds = $\left[\frac{\Delta t_o - 63}{32}\right]$ truncated to the nearest decimal integer. Δt_o is the desired coast duration in decimal seconds.	+28V (checkout power or internal power) to sw. regulator to +5V in CDU.	Playback of Coast Timer set data from Coast Timer telemetry Verification Circuit.
CLTIMC	Large Probe Timer Verification	"	"	"	"

SUBSYSTEM: (A.7) Communications

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RAGC1V	Receiver 1 Automatic Gain Control	AN (dBm)	90 Counts = -152.0 dBm; 205 Counts = -70.0 dBm.	Essential bus to (fuses to power converter to +9V & -6V lines in RCVR 1).	Resistive voltage divider at output of active AGC loop filter in RCVR 1.
RAGC2V	Receiver 2 Automatic Gain Control	AN (dBm)	90 Counts = -152.0 dBm; 201 Counts = -70.0 dBm.	Essential bus to (fuses to power converter to +9V & -6V lines in RCVR 2).	Resistive voltage divider at output of active AGC loop filter in RCVR 2.
RAMP1T	Power Amplifier 1 Temperature	AC (°F)	38 Counts = -298°F 215 Counts = +212°F	Sw. loads bus to DIM3 & precision 1.0 milliamp output.	Thermistor, P/N 908683-4.
RAMP2T	Power Amplifier 2 Temperature	AC (°F)	38 Counts = -298°F 215 Counts = +212°F	Sw. loads bus to DIM3 & precision 1.0 milliamp output.	Thermistor, P/N 908683-4.
RAMP3T	Power Amplifier 3 Temperature	AC (°F)	38 Counts = -298°F 216 Counts = +212°F	Sw. loads bus to DIM5 & precision 1.0 milliamp output.	Thermistor, P/N 908683-4.
RAMP4T	Power Amplifier 4 Temperature	AC (°F)	38 Counts = -298°F 215 Counts = +212°F	Sw. loads bus to DIM5 & precision 1.0 milliamp output.	Thermistor, P/N 908683-4.
RAMP1W	RF Power Output 1	AN (Watts)	90 Counts = 6.5 Watts; 217 Counts = 11.6 Watts.	Transmitter RF bus to (fuses to series reg. in power amp 1 unit).	RF pickup probe, rectified by a diode and amplified in Power Amp 1 Unit.
RAMP2W	RF Power Output 2	AN (Watts)	53 Counts = 6.5 Watts; 200 Counts = 12.0 Watts.	Transmitter RF bus to (fuses to series reg. in power amp 2 unit).	RF pickup probe, rectified by a diode and amplified in Power Amp 2 Unit.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Groupin...)

SUBSYSTEM: (A.7) Communications

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RAMP3W	RF Power Output 3	AN (Watts)	140 Counts = 6.5 Watts; 217 Counts = 11.7 Watts.	Transmitter RF bus to (fuses to series reg. in Power Amp 3 Unit).	RF pickup probe, rectified by a diode and amplified in Power Amp 3 Unit.
RAMP4W	RF Power Output 4	AN (Watts)	68 Counts = 6.5 Watts; 215 Counts = 11.8 Watts.	Transmitter RF bus to (fuses to series reg. in power amp 4 Unit).	RF pickup probe, rectified by a diode and amplified in Power Amp 4 Unit.
RSPE1V	Receiver 1 Static Phase Error	AN (kHz)	[illegible]3.8 Counts = +200.0 kHz; 201.9 Counts = -200.0 kHz.	Essential bus to (fuses to power converter to +9V & -6V lines in RCVR 1).	Resistive voltage divider at output of active loop filter in RCVR 1.
RSPE2V	Receiver 2 Static Phase Error	AN (kHz)	30.8 Counts = +200.0 kHz; 209.4 Counts = -200 kHz.	Essential bus to (fuses to power converter to +9V & -6V lines in RCVR 2).	Resistive voltage divider at output of active loop filter in RCVR 2.
RVCO1T	Receiver 1 VCO Temperature	AC (°F)	80.2 Counts = -22°F 171.4 Counts = +158°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Resistor, P/N TI RTH - 42.
RVCO2T	Receiver 2 VCO Temperature	AC (°F)	78.3 Counts = -22°F 173.3 Counts = +176°F	Sw. loads bus to DIM 5 & precision 1.0 milliamp output.	Resistor, P/N TI RTH - 42.
ROSC1T	Transmitter Auxiliary Oscillator 1 Temperature	AC (°F)	79.2 Counts = -22°F 175.5 Counts = +176°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Resistor, P/N TI RTH - 42.
ROSC2T	Transmitter Auxiliary Oscillator 2 Temperature	AC	82.7 Counts = -22°F 179 Counts = +176°F	Sw. loads bus to DIM 5 & precision 1.0 milliamp output.	Resistor, P/N TI RTH - 42.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.7) Communications

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RLOK1S	Receiver 1 Phase Lock Status	BL (None)	0 ≡ Not Locked; 1 ≡ Locked.	Essential bus to (fuse to power converter to +9V & -6V in RCVR 1).	Resistive voltage divider driven by LM 108A trigger circuit in RCVR 1.
RLOK2S	Receiver 2 Phase Lock Status	BL (None)	0 ≡ Not Locked; 1 ≡ Locked.	Essential bus to (fuse to power converter to +9V & -6V RCVR 2).	Resistive voltage divider driven by LM 108A trigger circuit in RCVR 2.
RCOH1S	Exciter 1 Inhibit/Restore Coherent Mode Status	BL (None)	0 ≡ Restore; 1 ≡ Inhibit.	Transmitter bus to (fuse to power converter to +9V & -6V in Exciter 1).	State of S/R Flip-flop in Exciter control module in Transponder 1.
RCOH2S	Exciter 2 Inhibit/Restore Coherent Mode Status	BL (None)	0 ≡ Restore; 1 ≡ Inhibit.	Transmitter bus to (fuse to power converter to +9V & -6V in Exciter 2).	State of S/R Flip-flop in Exciter control module in Transponder 2.
RXCT1S	Exciter ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Transmitter bus to (fuse to power converter to +9V in Exciter 1).	Resistive voltage divider in CMD interface module in Transponder 1.
RXCT2S	Exciter 2 ON/OFF	BL (None)	0 ≡ OFF; 1 ≡ ON.	Transmitter bus to (fuse to power converter to +9V in Exciter 2).	Resistive voltage divider in CMD interface module in Transponder 2.
RRCVRS	Receiver Reverse /Normal Switch Position	BL (None)	1 ≡ Reverse (aft omni to RCVR 1; a despun antenna to RCVR 2); 0 ≡ Normal (aft omni to RCVR 2); a despun antenna to RCVR 1).	Essential bus to (fuse in switch driver).	State of S/R flip-flop in switch driver, intended to indicate state of DPDT RF transfer switch between receivers and antennas. (See Note 3)

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.7) Communications

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RXCTRS	Exciter 1/2 Switch Position	BL (None)	0 = Exciter 2 Selected; 1 = Exciter 1 Selected.	Essential bus, to (fuse in switch driver)	State of S/R flip-flop in switch driver intended to indicate state of SPDT RF Transfer switch between Exciters & Power amps. (See Note 3).
RAMP1S	Amp 1/2 to Hi/ Low Power Status	BL (None)	0 = Amp 1 to Hi power output line (3 dB Hybrid); Amp 2 to Low Power output line). 1 = Amp 2 to Hi power output line; Amp 1 to Lo power output line.	Essential bus, to (Fuse in switch driver).	State of S/R flip-flop in switch driver intended to indicate state of DPDT RF Transfer switch between Amps and output lines to antennas (See Note 3).
RAMP3S	Amplifier 3/4 Switch Position	BL (None)	0 = Amp 4 Selected; 1 = Amp 3 Selected.	Essential bus, to (Fuse in switch driver).	State of S/R flip-flop in switch driver intended to indicate state of SPDT RF Transfer switch between Amps & Hi Power (3 dB Hybrid) output line (See Note 3).
RANT1S	Hi/Lo Power to AFT or (Horn/ FWD OMNI) Status	BL (None)	0 = Lo Power output line to Aft Omni; Hi Power output line to Horn or FWD antenna. 1 = Hi Power output line to Aft Omni; Lo Power output line to Horn or FWD Antenna.	Essential bus, to (Fuse in switch driver).	State of S/R flip-flop in switch driver intended to indicate state of DPDT RF Transfer Switch between output lines and antennas (See Note 3)
RANT2S	FWD OMNI/ Horn Switch Position	BL (None)	0 = HORN selected. 1 = FWD OMNI selected	Essential bus, to (Fuse in switch driver).	State of S/R flip-flop in switch driver intended to indicate state of SPDT RF Transfer Switch between one of two output RF lines and the two antennas. (See Note 3.)

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.5) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PB1P1T	Battery 1 Pack 1 Temperature	AC (°F)	41 Counts = +76°F 143 Counts = +32°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908635-4.
PB1P2T	Battery 1 Pack 2 Temperature	AC (°F)	41 Counts = +76°F 143 Counts = +32°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908635-4.
PB2P1T	Battery 2 Pack 1 Temperature	AC (°F)	41 Counts = +76°F 143 Counts = +32°F	Sw. loads bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908635-4.
PB2P2T	Battery 2 Pack 2 Temperature	AC (°F)	41 Counts = +76°F 143 Counts = +32°F	Sw. loads bus to DIM 6 & precision 1.0 milliamp output.	Thermistor, 908635-4.
PB1R1S	Battery 1, Relay 1 Status	BL (None)	0 = Lo Charge Selected; 1 = Hi Charge Selected.	Battery 1 or boost charge array 1 downstream of K1 & K2 wiper arms in chg/dischg controller 1.	Resistive divider, between Hi terminal of one pole of DPDT latching relay (K2) in charge/discharge controller 1 and signal ground.
PB2R1S	Battery 2, Relay 1 Status	BL (None)	0 = Lo Charge Selected; 1 = Hi Charge Selected.	Battery 2 or boost charge array 2 downstream of K1 & K2 wiper arms in chg/dischg controller 2.	Resistive divider, between Hi terminal of one pole of DPDT latching relay (K2) in charge/discharge controller 2, and signal ground.
PBAT1V	Battery 1 Terminal Voltage	AN (Volts)	0 Counts = 0 VDC 255 Counts = 39.93 VDC.	Battery 1 or boost charge Array 1 downstream of switching relays in charge/discharge controller 1.	Resistive divider, between positive terminal of Battery 1 & signal ground.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.8) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PBAT2V	Battery 2 Terminal Voltage	AN (Volts)	0 Counts = 0 VDC 255 Counts = 39.92 Volts.	Battery 2 or boost charge array 2 downstream of switching relays in Chg/disch. Controller 2.	Resistive divider, between positive terminal of Battery 2 & signal ground.
PB1R2S	Battery 1, Relay 2 Status	BL (None)	0 = Lo Charge Selected; 1 = Hi Charge Selected.	Battery 1 or boost charge array 1, downstream of K1 & K2 wiper arms in chg/dischg. controller 1.	Resistive divider, between Hi terminal of one pole of DPDT latching relay (K1) in charge/discharge controller 1, and signal ground.
PB2R2S	Battery 2, Relay 2 Status	BL (None)	0 = Lo Charge Selected; 1 = Hi Charge Selected.	Battery 2 or boost charge array 2, downstream of K1 & K2 wiper arms in charge/discharge controller 2.	Resistive divider, between Hi terminal of one pole of DPDT latching relay (K1) in charge/discharge controller 2, and signal ground.
PHTTKS	Primary/ Secondary Propulsion Tank Heaters Status	BL (None)	0 = Secondary heaters selected; 1 = Primary heaters selected.	Essential bus, downstream of heaters select relay.	Resistive divider between power line to primary heaters (& upstream of fuses) and signal ground (in PIU).
PLDBUS	Switched Loads Bus Reset Relay Status	BL (None)	0 = Switched loads UV/OL Relay has tripped Bus OFF. 1 = Switched loads UV/OL Relay has not tripped (Bus ON).	Switched loads bus downstream of UV/ OL switch (K2).	Resistive divider between terminal of one pole of DPST (Normally closed) latching relay (K2) controlled by UV/OL trip circuit, and signal ground.
PLIM1S	Bus Limiter 1 Enable/Disable	BL (None)	0 = Disabled; 1 = Enabled.	Essential bus (Main array output).	Resistive divider, between terminal of SPST latching relay and signal ground, in Bus Limiter 1.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.8) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PPANLI	Solar Panel Current	AN (Amps)	0 Counts = 0.0 Amps; 256 Counts = +18.0 Amps.	Essential bus at output of main array.	Dual 50 mV current shunt and a hybrid differential amplifier.
PREG1S	Primary/ Redundant Discharge Regulator 1 Status	BL (None)	0 = Redundant selected in Controller #1. 1 = Primary selected in Controller #1.	Essential bus downstream of primary discharge regulator in Charge/Discharge Controller #1.	Resistive divider, between output of Primary Discharge Regulator and Signal Ground (in Charge/Discharge Controller #1).
PREG2S	Primary/ Redundant Discharge Regulator 2 Status	BL (None)	0 = Redundant selected in Controller #2. 1 = Primary selected in Controller #2.	Essential bus downstream of primary discharge regulator in Charge/Discharge Controller #2.	Resistive divider, between output of primary discharge regulator & signal ground (in charge/discharge Controller #2).
PRFBUS	RF XMTR Bus Reset Relay Status	BL (None)	0 = XMTR bus UV/OL Relay has tripped Bus OFF; 1 = XMTR bus UV/OL Relay has not tripped (Bus ON).	XMTR Bus, downstream of UV/OL switch (K3).	Resistive divider between terminal of one pole of DPST (normally closed) latching relay (K3) controlled by UV/OL trip circuit, and signal ground.
PSCBUS	Science Bus Reset Relay Status	BL (None)	0 = Science bus UV/OL has tripped Bus OFF. 1 = Science Bus UV/OL Relay has not tripped (Bus ON).	Science Bus, downstream of UV/OL switch (K1).	Resistive divider between terminal of one pole of DPST (normally closed) latching relay (K1) controlled by UV/OL trip circuit, and signal ground.
PSCICI	Science Current	AN (Amps)	0 Counts = 0 Amps 255 Counts = 1.5 Amps	Science Bus, downstream of UV/OL switch.	Dual 50 mV current shunt and a hybrid differential amplifier.
PSPROS	Power System Protection ON/ OFF	BL (None)	0 = OFF (UV/OL Logic bypassed; all buses ON). 1 = ON (UV/OL Logic controls ON/OFF state for each of three buses).	Essential Bus, downstream of Relay K5 (in UV/OL switch unit).	For DIM2: Resistive divider between ON terminal of SPST latching Relay (K5) & signal ground (in UV/OL sw. Unit). For DIM4: Separate resistive divider from above, tied to same [illegible] as for divider above.

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APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.8) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PLIM2S	Bus Limiter 2 Enable/Disable	BI (None)	0 = Disabled; 1 = Enabled.	Essential Bus (Main array output)	Resistive divider, between terminal of SPST latching relay and signal ground, in Bus Limiter 2.
PLIM3S	Bus Limiter 3 Enable/Disable	BI (None)	0 = Disabled; 1 = Enabled.	Essential Bus (Main array output)	Resistive divider, between terminal of SPST latching relay and signal ground, in Bus Limiter 3.
PLIM4S	Bus Limiter 4 Enable/Disable	BI (None)	0 = Disabled; 1 = Enabled.	Essential Bus (Main array output)	Resistive divider, between terminal of SPST latching relay and signal ground, in Bus Limiter 4.
PLIM5S	Bus Limiter 5 Enable/Disable	BI (None)	0 = Disabled; 1 = Enabled.	Essential Bus (Main array output)	Resistive divider, between terminal of SPST latching relay and signal ground, in Bus Limiter 5.
PLIMTI	Bus Voltage Limiter Current	AN (Amps)	0 Counts = 0.0 Amps; 256 Counts = +12.0 Amps.	Essential Bus (Main array output to all Bus Limiters).	Dual 50 mV current shunt and a hybrid differential amplifier.
PPAN1T	Solar Panel Temperature 1	AC (°F)	38 Counts = -298°F 215 Counts = +212°F	Sw. loads bus to DIM 3 & precision 1.0 milliamp output.	Platinum resistor, 908683-4.
PPAN2T	Solar Panel Temperature 2	AC (°F)	38 Counts = -298°F 215 Counts = +212°F	Sw. loads bus to DIM 7 & precision 1.0 milliamp output.	Platinum resistor, 908683-4.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.8) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PRCHGS	Precharge ON/OFF Status	BL (None)	0 = OFF; 1 = ON.	Essential bus downstream of 1 amp current limited switch (In UV/OL Switch Unit).	Resistive divider between output of 1 amp current limited switch and signal ground (In UV/OL Switch Unit).
PBUSLI	Spacecraft Loads Current	AN (Amps)	0 Counts = 0.0 Amps; 256 Counts = +18.0 Amps.	Essential bus, just upstream from fan-out to four buses.	Dual 50 mV current shunt and a hybrid differential amplifier.
PCHG1I	Battery 1 Charge Current	AN (Amps)	0 Counts = 0 Amps; 256 Counts = 1.0 Amps.	At output of boost charge array 1 & downstream of chg. switching relays in chg/disch controller #1.	Dual 50 mV current shunt and a hybrid differential amplifier (In Charge/Discharge Controller 1).
PCHG2I	Battery 2 Charge Current	AN (Amps)	0 Counts = 0 Amps; 256 Counts = 1.0 Amps.	At output of boost charge array 2, & downstream of chg. switching relays in chg/disch.controller #2.	Dual 50 mV current shunt and a hybrid differential amplifier (In charge/discharge controller #2).
PDIS1I	Battery 1 Discharge Current	AN (Amps)	0 Counts = 0 Amps; 256 Counts = 12.0 Amps.	Battery 1 between Battery 1 & disch. Regulators in chg/disch controller #1.	Dual 50 mV current shunt and a hybrid differential amplifier (In charge/discharge controller #1).
PDIS2I	Battery 2 Discharge Current	AN (Amps)	0 Counts = 0 Amps 256 Counts = 12.0 amps.	Battery 2 between battery 2 & disch. Regs. in chg/disch. controller #2.	Dual 50 mV current shunt and a hybrid differential amplifier (In charge/discharge controller #2).

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.8) Power

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PEBUSV	Essential Bus Voltage	AN (Volts)	0 Counts - 0 Volts; 255 Counts = +34.92 V.	Essential bus (In UV/OL Switch Unit)	For DIM3: Resistive divider between essential bus & signal ground (In UV/OL Switch Unit). For DIM5: Separate resistive divider from above, tied to same points as for divider above
PHTAJS	Aft Axial Jet Heaters ON/OFF	BL (None)	0 OFF, 1 ON.	Essential Bus, downstream of two DPST relays in series (heater select relays).	Resistive divider between terminal of one pole of DPST latching relay and signal ground (In PIU).
PHTFJS	Fwd Axial Jet Heaters ON/OFF	BL (None)	0 OFF; 1 - ON.	Essential Bus downstream of single DPST relay (heater select relay).	"
P1HTRS	Small Probe 1 Heater ON/OFF	BL (None)	0 OFF; 1 - ON.	"	"
P2HTRS	Small Probe 2 Heater ON/OFF	BL (None)	0 - OFF, 1 ON.	"	"
P3HTRS	Small Probe 3 Heater ON/OFF	BL (None)	0 OFF, 1 ON.	"	"
PLHTRS	Large Probe Heater ON/OFF	BL (None)	0 OFF; 1 ON.	"	"
PCHEKS	Probe Checkout Power ON/OFF	BL (None)	0 OFF, 1 ON.	Essential Bus downstream of single 4-PST relay (heater select relay).	Resistive divider between terminal of one pole of 4-PST latching relay and signal ground (In PIU).

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.9) Small Probe 1 TM Via Bus DIM(s)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
P1PR1S	Small Probe 1 Internal Power Relay 1 ON/OFF	BL (None)	0 ≡ Relay #1 not activated. 1 ≡ Relay #1 activated.	Switched Loads to DIM 4 & precision 1.0 milliamp output.	State of one pole of 4 PST Relay #1 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #1 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P1PR2S	Small Probe 1 Internal Power Relay 2 ON/OFF	BL (None)	0 ≡ Relay # 2 not activated. 1 ≡ Relay #2 activated.	"	State of one pole of 4 PST Relay #2 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P1BATT	Small Probe 1 Battery Temperature	AC (°F)		Switched Loads to DIM 4 & precision 1.0 milliamp output.	Thermistor, 908631-32
P1HTBS	Small Probe 1 Battery Heater Relay ON/OFF.	BL (None)	0 ≡ No power to Battery Heater 1 ≡ Probe internal power connected to thermostatically-controlled Battery Heater.	Science Bus to checkout Bus to Probe internal power line to down-stream side of Battery Heater Relay	State of Battery Heater Relay that is closed (provides probe internal power to thermostatically controlled heater) prior to timer timeout, & open (no power) after timer timeout.
S1AF1T	Small Probe 1 AFT Shelf Temp #1	AC (°F)	90 Counts = -29°F 162 Counts = +116°F	Switched Loads Bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
S1FW1T	Small Probe 1 FWD Shelf Temp #1	AC (°F)	"	"	"

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.10) Small Probe 2 TM Via Bus DIM(s)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
P2PR1S	Small Probe 2 Internal Power Relay 1 ON/OFF	BL (None)	0 ≡ Relay #1 not activated. 1 ≡ Relay #1 activated	Switched Loads to DIM 4 & precision 1.0 milliamp output.	State of one pole of 4 PST Relay #1 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #1 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P2PR2S	Small Probe 2 Internal Power Relay 2 ON/OFF	BL (None)	0 ≡ Relay # 2 not activated. 1 ≡ Relay #2 activated.	"	State of one pole of 4 PST Relay #2 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P2BATT	Small Probe 2 Battery Temperature	AC (°F)		Switched Loads to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
P2HTBS	Small Probe 2 Battery Heater Relay ON/OFF.	BL (None)	0 ≡ No power to Battery Heater 1 ≡ Probe internal power connected to thermostatically-controlled Battery Heater.	Science Bus to checkout Bus to Probe internal pwr. line to downstream side of Battery Heater Relay	State of Battery Heater Relay that is closed (provides probe internal power to thermostatically controlled heater) prior to timer timeout, & open (no power) after timer timeout.
S2AF1T	Small Probe 2 AFT Shelf Temp #1	AC (°F)	90 Counts = +3°F 162 Counts = +138°F	Switched Loads Bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
S2FW1T	Small Probe 2 FWD Shelf Temp #1	AC (°F)	90 Counts = -12°F 162 Counts = +123°F	"	"

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.11) Small Probe 3 TM Via Bus DIM(s)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
P3PR1S	Small Probe 3 Internal Power Relay 1 ON/OFF	BL (None)	0 = Relay #1 not activated. 1 = Relay #1 activated.	Switched Loads to DIM 4 & precision 1.0 milliamp output.	State of one pole of 4 PST Relay #1 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #1 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P3PR2S	Small Probe 3 Internal Power Relay 2 ON/OFF	BL (None)	0 = Relay # 2 not activated. 1 = Relay #2 activated.	"	State of one pole of 4 PST Relay #2 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
P3BATT	Small Probe 3 Battery Temperature	AC (^{o}F)		Switched Loads to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
P3HTBS	Small Probe 3 Battery Heater Relay ON/OFF.	BL (None)	0 = No power to Battery Heater 1 = Probe internal power connected to thermostatically-controlled Battery Heater.	Science Bus to checkout Bus to Probe internal pwr. line to down-stream side of Battery Heater Relay	State of Battery Heater Relay that is closed (provides probe internal power to thermostatically controlled heater) prior to timer timeout, & open (no power) after timer timeout.
S3AF1T	Small Probe 3 AFT Shelf Temp #1	AC (^{o}F)	90 Counts = -13.5^{o}F 162 Counts = +121^{o}F	Switched Loads Bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
S3FW1T	Small Probe 3 FWD Shelf Temp #2	AC (^{o}F)	90 Counts = -10^{o}F 162 Counts = +125^{o}F	"	"

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.12) Large Probe TM Via Bus DIM(s)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PLPR1S	Large Probe Internal Power Relay 1 ON/OFF	BL (None)	0 = Relay #1 not activated. 1 = Relay #1 activated.	Switched Loads to DIM 4 & precision 1.0 milliamp output.	State of one pole of 4 PST Relay #1 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #1 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
PLPR2S	Large Probe Internal Power Relay 2 ON/OFF	BL (None)	0 = Relay # 2 not activated. 1 = Relay #2 activated.	"	State of one pole of 4 PST Relay #2 that is powered by Essential Bus. When both not activated, Relays #1 & #2 provide, in series, Probe Checkout Power to the Probe Bus. When either Relay #1 or #2 is activated, the Probe Battery is connected to the Probe Bus. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
PLBATT	Large Probe Battery Temperature	AC (°F)		Switched Loads to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
PLHTRS	Large Probe Battery Heater Relay ON/OFF.	BL (None)	0 = No power to Battery Heater 1 = Probe internal power connected to thermostatically-controlled Battery Heater.	Science Bus to checkout Bus to Probe internal powerline to downstream side of Battery Heater Relay	State of Battery Heater Relay that is closed (provides probe internal power to thermostatically controlled heater) prior to timer timeout, & open (no power) after timer timeout.
SLAF1T	Large Probe AFT Shelf Temp #1	AC (°F)	64 counts = -85°F 263 counts = +256°F	Switched Loads Bus to DIM 1 & precision 1.0 milliamp output.	Thermistor, 908631-32
SLFW1T	Large Probe FWD Shelf Temp #1	AC (°F)	90 Counts = -6°F 162 Counts = +129°F	"	"

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.13) Small Probe X TM Via C/DU & Small Probe Subcarrier (4096 Hz) (X=1 or 2 or 3)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PXBUSI	Small Probe X Bus Current	AN (AMPS)	0 counts = 0.0 amps SP1 & SP3: 253 counts = 4.5 amps SP2: 226 counts = 4.0 amps	Probe Bus: i.e., the Probe Battery Bus (i.e. internal) OR Science Bus via Probe Check-out Bus	Voltage across shunts in Hybrid current sensor (HAC #909949)
PXBUSV	Small Probe X Bus Voltage	AN (Volts)	0 counts = 0 VDC SP1, SP2, & SP3: 211 Counts = 33.0 VDC.	"	Output of voltage divider that is connected between Probe Bus and and signal ground $\left(\frac{7.68 \text{ k ohm}}{60 \text{ k ohm}}\right)$
PXCD1S	Small Probe X C/DU and RF Power Relay 1 ON/OFF	BL (None)	0 ≡ Relay #1 not activated 1 ≡ Relay #1 activated	Precision 1.0 milliamp from C/DU	State of one pole of 4 PST Relay #1 that is powered by Probe Bus. When activated, Relay #1 provides Probe Bus power to the C/DU, Exciter, Drive Amplifier, R.F. Power Amplifier, PCU Drivers, Nephelometer Window Heater Relay, Science Primary Relay, & Science Secondary Relay. When Relay #1 is activated, one pole is open-circuited; when relay 's not activated, the one pole is signal-grounded.
PXCD2S	Small Probe X C/DU and RF power Relay 2 ON/OFF	BL (None)	0 ≡ Relay #2 not activated 1 ≡ Relay #2 activated	"	State of one pole of 4 PST Relay #2 that is powered by Probe Bus. When activated, Relay #2 provides Probe Bus power to the C/DU, Exciter, Drive Amplifier, R.F. Power Amplifier, PCU Drivers, Nephelometer Window Heater Relay, Science Primary Relay, & Science Secondary Relay. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A, 13) Small Probe X TM Via C/DU & Small Probe Subcarrier (4096 Hz) (X=1 or 2 or 3)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PXHTWS	Small Probe X SN Window Heater	BL (None)	0 ≡ Heater Power OFF 1 ≡ Heater Power ON	Probe Bus	Output of voltage divider that is connected between Window Heater Power line (downstream of both poles of 2 PST Nephelometer window heater relay that is powered by C/DU Bus) and signal ground. $\left(\frac{9.76\ k\ ohm}{62.06\ k\ ohm}\right)$

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.13) Small Probe X TM Via C/DU & Small Probe Subcarrier (4096 Hz) (X=1 or 2 or 3)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & (UNITS)	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PXSP1S	Small Probe X Science Power Primary Relay ON/OFF	BL (None)	0≡Primary Relay not activated 1≡Primary Relay activated	Probe Bus	Output of voltage divider that is connected between downstream side of one pole of 4 PST Primary Relay (that is powered by C/DU Bus) and signal ground. Upstream side of pole is connected to Probe Bus. ($\frac{9.76 \text{ k ohm}}{52.06 \text{ k ohm}}$).
PXSP2S	Small Probe X Science Power Backup Relay ON/OFF	BL (None)	0≡Backup Relay not activated 1≡Backup Relay activated		Output of voltage divider that is connected between downstream side of one pole of 4 PST Backup Relay (that is powered by C/DU Bus) and signal ground. Upstream side of pole is connected to Probe Bus. ($\frac{9.76 \text{ k ohm}}{52.06 \text{ k ohm}}$)
RXOSCS	Small Probe X Stable Oscillator ON/OFF	BL (None)	0≡Oscillator Power OFF 1≡Oscillator Power ON	"	Output of voltage divider that is connected between Stable Oscillator Powerline (downstream of both poles of 2 PST Stable Oscillator Power Relay that is powered by Probe Bus) and signal ground. ($\frac{9.76 \text{ k ohm}}{52.06 \text{ k ohm}}$)
RXHTOV	Stable Oscillator Heater Voltage	AN (Volts)	0 counts = 0.0 volts 225 counts = 5.1 volts	Science Bus to Probe Internal Bus to hot side of heater (R1)	Resistive voltage divider output ($\frac{22 \text{ k ohm}}{122 \text{ k ohm}}$) - connected between (tap point between oven heater & Q1 Xsistor) and DC return.
SXINTP	Internal Pressure	AN (PSIA)	10 Counts = 0 PSIA 250 Counts = 50 PSIA	Science Bus to Probe Internal Bus	Pressure transducer - effective "wiper arm" output of potentiometer connected between Probe Internal Bus & Ground.
SXASBS	SAS Boom Deploy Status	BL (None)	0 = not deployed 1 = Deployed	Precision 1.0 milliamp from C/DU	State of switch that is closed & connected to signal ground for undeployed state; and open-circuited for deployed state.

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A, 13) Small Probe X TM Via C/DU & Small Probe Subcarrier (4096 Hz) (X=1 or 2 or 3)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
SXFRBS	SNFR Boom Deploy Status	BL (None)	0 = Not deployed 1 = Deployed	Precision 1.0 milliamp from C/DU	State of switch that is closed & connected to signal ground for undeployed state; and open-circuited for deployed state.
SXAF2T	(Small Probe X) Aft Shelf Temp.	AC (°F)	COUNTS: SP1 / SP2 / SP3 ; DEGREES F: SP1 / SP2 / SP3 102 / 90 / 90 ; -13 / -6 / -15 142 / 162 / 162 ; +50 / +129 / +120	Precision 1.0 Milliamp from C/DU	Thermistor, HAC #908681-32
SXFW2T	(Small Probe X) Fwd Shelf Temp	AC (°F)	COUNTS: SP1 / SP2 / SP3 ; DEGREES F: SP1 / SP2 / SP3 103 / 90 / 90 ; -21 / -6 / -63 141 / 162 / 226 ; +84 / +129 / +215	"	"
MRO	Data Storage Memory Readout	SD (3072 bits in 8 bit groups)	Any telemetry data Readout	Science Bus to Probe Internal Bus to C/DU Power Supply to +5 VDC & -12 VDC lines	Output of Unit CD17 in C/DU; a 30?? bit serial in/serial out shift register.
DXCDUT	Small Probe X CDU Oscillator Temperature	AC (°F)	COUNTS: SP1 / SP2 / SP3 ; DEGREES F: 19 / 19 / 19 ; +160° 234 / 253 / 252 ; -40.0	Precision 1.0 Milliamp from C/DU	Thermistor, HAC #908684-3
Yo	Thermocouple Junction Temp.	AC (°F)	53 counts = -100°F 255 counts = +448°F	Precision 1.0 Milliamp from C/DU	Resistance Thermometer GE# 47C51560001
Ya	Stagnation Region Temp.	AC (°F)	COUNTS: SP1 / SP2 / SP3 ; DEGREES F: SP1 / SP2 / SP3 0 / 0 / 0 ; 0 / 0 / 0 246 / 249 / 248 ; +2414 / +2402 / +2414	Generates own Voltage	Thermocouple - GE# 47D51554208
Yh	Frustrum Region Temp.	AC (°F)	COUNTS: SP1 / SP2 / SP3 ; DEGREES F: SP1 / SP2 / SP3 0 / 0 / 0 ; 0 / 0 / 0 247 / 249 / 248 ; +2414 / +2402 / +2415	"	Thermocouple - GE#47D51554207

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.14) Large Probe TM Via C/DU & Large Probe Subcarrier (8192 Hz)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PLBUSI	Large Probe Bus Current	AN (Amps)	0 counts = 0.0 Amps 255 counts = 18.0 Amps	Probe Bus: i.e. the Probe Battery Bus (i.e. internal) OR Science Bus Via Probe Check-out Bus	Voltage across shunts is Hybrid Current Sensor (HAC #909949)
PLBUSV	Large Probe Bus Voltage	AN (Volts)	0 counts = 0 VDC 210.5 counts = 33.0 VDC	"	Output of voltage divider that is connected between Probe Bus and signal ground. (7.68 k ohm / 80 k ohm)
PLCD1S	(Large Probe) C/DU Power Relay #1 ON/OFF	BL (None)	0 = Relay #1 activated 1 = Relay #1 activated	Precision 1.0 Milliamp from C/DU	State of one pole of 4 PST Relay #1 that is powered by Probe Bus. When activated, Relay #1 provides Probe Bus power to the C/DU, Pressure Gage, PCU Control, IR window heater relays, RF subsystem power relay, Window & Prism heater relay, & Science Primary & Secondary Relays. When Relay #1 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
PLC2S	(Large Probe) C/DU Power Relay #2 ON/OFF	BL (None)	0 = Relay #2 not activated 1 = Relay #2 activated	"	State of one pole of 4 PST Relay #2 that is powered by Probe Bus. When activated, Relay #2 provides Probe Bus power to the C/DU, Pressure Gage, PCU Control, IR window heater relays, RF subsystem power relay, Window & Prism heater relay, & Science Primary & Secondary Relays. When Relay #2 is activated, one pole is open-circuited; when relay is not activated, the one pole is signal-grounded.
PLSP1S	(Large Probe) Science Power Primary Relay ON/OFF.	BL (None)	0 = Primary Relay not activated 1 = Primary Relay activated	Probe Bus	Output of voltage divider that is connected between downstream side of one pole of 4 PST Primary Relay (that is powered by C/DU Bus) and signal ground. (9.76 k ohm / 62.94 k ohm)
PLSP2S	(Large Probe) Science Power Backup Relay ON/OFF	BL (None)	0 = Backup Relay not activated 1 = Backup Relay activated	"	Output of voltage divider that is connected between downstream side of one pole of 4 PST backup Relay (that is powered by C/DU Bus and signal ground. (9.76 k ohm / 62.06 k ohm)

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.14) Large Probe TM Via C/DU & Large Probe Subcarrier (8192 Hz)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
PLHTWS	Window & Prism Heaters ON/OFF	BL (None)	0 = Heater Power OFF 1 = Heater Power ON	Probe Bus	Output of voltage divider that is connected between Window & Prism Heaters Power line (downstream of both poles of 2 PST Relay that is powered by C/DU Bus) and signal ground. $\left(\frac{9.76 \text{ k ohm}}{62.06 \text{ k ohm}}\right)$
PLHT1S	LIR Window Heater 1st Stage ON/OFF	BL (None)	0 = IR Window Heater Power OFF 1 = IR Window Heater Power ON	"	Output of voltage divider that is is connected between 1st Stage IR Window Heater Power line (downstream of both poles of 2 PST Relay that is powered by C/DU Bus) and signal ground $\left(\frac{9.76 \text{ k ohm}}{62.06 \text{ k ohm}}\right)$
PLHT2S	LIR Window Heater 2nd Stage ON/OFF	BL (None)	0 - 2nd Stage Window Heater Relay not activated 1 = 2nd Stage Window Heater activated and IR Window Heater Power ON.	"	Output of voltage divider that is connected between IR Window Heater Power line (downstream of both poles of 2 PST 1st Stage Window Heater Relay that is powered by C/DU Bus) and signal ground. $\left(\frac{9.76 \text{ k ohm}}{62.06 \text{ k ohm}}\right)$ Additionally this TM tap point is also connected to the downstream side of one pole of 2 PST 2nd Stage Window Heater Relay that is powered by the C/DU Bus. The upstream side of this one pole is connected to power ground.
PLRCVS	Receiver ON/OFF	BL (None)	0 - Receiver Power OFF 1 - Receiver Power ON	"	Output of voltage divider that is connected between Receiver Power line (downstream of both poles of 2 PST Receiver Power Relay that is powered by Probe Bus) and Signal Ground. $\left(\frac{9.76 \text{ k ohm}}{62.06 \text{ k ohm}}\right)$

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.14) Large Probe TM Via C/DU & Large Probe Subcarrier (8192 Hz)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
RLVCOT	Receiver VCO Temp.	AC (°F)	93 counts = -22°F 203 counts = +176°F	Precision 1.0 Milliamp from C/DU	Resistor, P/N TI RTH-42
RLOSCT	Transmitter *Aux. Osc. Temp.*	AC (°F)	83 counts = -22°F 180 counts = +176°F	"	"
RLAGCV	Receiver AGC Voltage	AN (volts or DBM)	100 counts = -152 DBM 207 counts -70.0 DBM	Probe Internal Bus to (fuses to pwr. conv. to +9V & -6V. lines in the receiver).	Resistive voltage divider at output of active AGC loop filter in the receiver.
RLSPEV	Receiver Static Phase Error	AN (KHz)	43 counts = +200 KHz 207 counts = -200 KHz	"	Resistive voltage divider at output of active loop filter in the receiver.
SLINTP	Internal Pressure	AN (psia)	11.4 counts = 0 PSIA 252 counts = 50.0 PSIA	Science Bus to Probe Internal Bus	Pressure transducer - effective "wiper arm" output of potentiometer connected between Probe Internal Bus & Ground.
SLAF2T	(Large Probe) Aft Shelf Temp.	AC (°F)	100 Counts = +23°F 126 Counts = +73°F	Precision 1.0 Milliamp from C/DU	Thermistor HAC #908631-32
SLFW2T	(Large Probe) Fwd. Shelf Temp.	AC (°F)	107 Counts = +25°F 147 Counts = +82°F	"	"
SLIRWT	LIR Window Temp.	AC (°F)	81 counts = -4°F 258 counts = +968°F	Precision 1.0 Milliamp from C/DU	Thermistor, HAC #259162 (modified #259202)
MRO	Data Storage Memory Readout	SD (3072 bits in 8 bit groups)	Any telemetry data readout	Science Bus to Probe Internal Bus to C/DU Pwr. Supply to +6VDC & -12 VDC lines	Output of Unit CD17 in C/DU: a 3072 bit serial in/serial out shift register

APPENDIX A: TELEMETRY REFERENCE DATA (By S/C Subsystem Grouping)

SUBSYSTEM: (A.14) Large Probe TM Via C/DU & Large Probe Subcarrier (8102 Hz)

TM MNE-MONIC	TELEMETRY TITLE	TM TYPE & UNITS	TELEMETERED RANGE	POWER SOURCE	SOURCE DERIVATION AND REMARKS
DLCDUT	Large Probe CDU Osc. Temp.	AC (°F)	20.7 counts = +160°F 248 counts = -40°C	Precision 1.0 Milliamp from C/DU	Thermistor, HAC #908632-2
Ya	Stagnation Region Temp.	AC (°F)	0 counts = +32°F 248 counts = +2412°F	Generates own voltage	Thermocouple, GE#47C51543G1
Yb	Frustrum Region Temp.	AC (°F)	0 counts = +32°F 248 counts = +2416°F	"	Thermocouple, GE# 47C51543G6
Yd	Heat Shield Backface Temp.	AC (°F)	53 counts = -100°F 255 counts = +448°F	Precision 1.0 Milliamp from C/DU	Resistance Thermometer, GE #47C515600G1
Yc	Thermocouple Junction Temp.	AC (°F)	"	"	"

NOTES

NOTE 1: AN = Analog = 8 Bits

BL = Bilevel = 1 Bit

SD = Serial Digital (Various numbers of Bits)

NOTE 2: All analog telemetered ranges are 0 counts to 255 counts. The data shown are the maximum and minimum points of actual calibration data used in the Multiprobe TM Conversion Handbook, Reference: Paragraph 1.5.16.

NOTE 3: Flip-flop resets for powr source OFF condition, whereas RF Xfer switch remains latched to last commanded state.

APPENDIX B

TELEMETRY REFERENCE DATA

(MNEMONICS IN ALPHABETICAL ORDER)

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APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT -	STATUS 0 BIT -	STATUS MULT	E V CONVERSION UNIT	E V CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
AACSAD	ACS Angle Delay Magnitude	B,0	BACS, OACS	18(6-7),19	SD	-	-	-	DEG	.352	.352-360 DEG		18(6)=LSB
AADP2S	Att Data Processor 1 Power Status	B,0	BSUBA, OSUBA	3(0),3(0)	BL	ON	OFF	-	-	-	-	-	
AADP2S	" " " 2 " "	B,0	, OSUBA	3(1),3(1)	BL	ON	OFF	-	-	-	-	-	
ABAPIT	BAPTA Inner Race Bearing Temp	0	SUBB	19	AC	-	-	-	°C	-	+49.0 to +4.0	-	
ABAPOT	" Outer " " "	0	SUBB	20	AC	-	-	-	°C	-	+70.0 to -20.0	-	
ADCE1T	Despin Control Electronics 1 Temp	0	SUBB	40	AC	-	-	-	°C	-	-10.0 to + 50.0	-	
ADCE2T	" " " 2 "	0	SUBB	48	AC	-	-	-	°C	-	-10.0 to + 70.0	-	
ADCE1V	" " " 1 Pwr Supply Volt.	0	SUBB	41	AN	-	-	-	Volts	-	0.0 to 5.1	-	
ADCE2V	" " " 2 " " "	0	SUBB	49	AN	-	-	-	Volts	-	0.0 to 5.1	-	
ADSPHS	" Phase Reset Status	0	SUBB	30(0)	SD	ENAB	DSAB	-	-	-	-	-	
ADVANS	SRR Advance Status	B,0	BACS, OACS	16(4)	SD	ADV	REST	-	-	-	-	-	
AELEVD	HGA Elevation Position (Dish)	0	LACR, ENGR,	23,55	AN	-	-	-	DEG	-	±16.0°	-	
		0	SUBA	13,45	AN	-	-	-	DEG	-	±16.0°	-	
AJCE1S	Jet Control Electronics 1 Buffer Output Status	B,0	BSUBA, OSUBA	3(2)	BL	ON	OFF	-	-	-	-	-	
AJCE2S	" " " 2 " " "	B,0	BSUBA, OSUBA	3(3)	BL	ON	OFF	-	-	-	-	-	
AJCEFS	" " " Fire Status	B,0	BACS, OACS	15(0)	BL	ENAB	DSAB	-	-	-	-	-	
AJETMS	Jet Fire Mode Status	B,0	BACS, OACS	13(6)+14(0)	SD	00=APUL	01=NPUL	11=CONT	-	-	-	-	
AJET1S	Radial Jet 1 Status	B,0	BACS,OACS	14(1)	SD	ENAB	DSAB	-	-	-		-	
AJET2S	" " 2 "	B,0	BACS, OACS	14(2)	SD	ENAB	DSAB	-	-	-	-	-	
AJET3S	" " 3 "	B,0	BACS, OACS	14(3)	SD	ENAB	DSAB	-	-	-	-	-	
AJET4S	" " 4 "	B,0	BACS, OACS	14(4)	SD	ENAB	DSAB	-	-	-		-	
AJET5S	Axial Jet 5 Status	B,0	BACS, OACS	14(5)	SD	ENAB	DSAB	-	-	-	-	-	
AJET6S	" " 6 "	B,0	BACS, OACS	14(6)	SD	ENAB	DSAB	-	-	-	-	-	
AJET7S	" " 7 "	0	ACS	14(7)	SD	ENAB	DSAB	-	-	-	-	-	
AJMAGC	JCE Countdown (Magnitude)	B,0	BACS, OACS	12+13(0-3)	SD	-	-	-	Counts Sec		0-4095 0-2096.645	-	
ALLCKS	PLL Loss-Of-Lock Status	B,0	BACS, OACS	18(0)	SD	LOCK	LOSS	-	-	-	-	-	
ALOLES	PLL Loss-Of-Lock Enable Status	B,0	BACS, OACS	16(2)	SD	ENAB	INHB	-	-	-	-	-	
AJETCD	Time From SRR to Jet Firing	B,0	N/A	N/A	CALC	-	-	-	DEG		0-360	-	04/3.4.10.3
AJETCK	Thruster Firings	B,0	N/A	N/A	CALC	-	-	-	Counts	-	-	-	04/3.4.4.10.2

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS: BIT=1	STATUS: "0" BIT=	STATUS: MULT	E V CONVERSION: UNIT	E V CONVERSION: QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
AM1ADS	Attitude Measurement 1 Address	B,0	BETY,	18(0-2)	SD	000=0=S	BR(Sel.	Roll Ref	-	-	-	-	Bit 0 = LSB
			BACS, OACS	10(0-2)		100-1=M	S(Minor	Fr.Sync	-			-	
						010=2=R	P(Roll	nd. Pul	-	-	-	-	
						110-3-M	P(Mast.	ndx Pul)	-	-	-	-	
						001=4=G	YB(Gated	Star B)	-	-	-	-	
						101=5=	S2S (Ps	2)	-	-	-	-	
						011=6=M	AS(Maj.	Fr. Sync	-	-	-	-	
AM2ADS	Attitude Measurement 2 Address	B,0	BETY,	18(3-5)	SD	000=0=S	BR(Sel	Roll Ref)		-	-	-	Bit 3 = LSB
			BACS,OACS	10(3-5)		100=1=M	S(Minor	Fr.Sync		-	-	-	
						010=2=R	P(Roll	ndx Pul	-	-	-	-	
						110=3=M	P(Mast.	Indx Pul	-	-	-	-	
						001=4=G	YB(Gated	Star B)	-	-	-	-	
						101=5=	S2S (Ps	2)	-	-		-	
						011=6=M	AS(Maj.	Fr. Sync)	-	-	-	-	
AMAGCS	Jet Pulse/Time Count Select Status	B,0	BACS,OACS	13(5)	SD	PULS	Time	-	-	-	-	-	
AMISSC	Missed SRR Count	B,0	BACS, OACS	18(1-4)	SD		-	-	Count	1	0-8 Counts	-	Bit 1 = LSB
AMOTRI	Despin Motor Drive Current	0	ENG,SUBB,	59,42	AN	-	-	-	Amps	-	0.0 to 1.2	-	
AMTR1S	" " " 1 Status	0	SUBA,	3(6)	BL	ON	OFF	-	-	-	-	-	
AMTR2S	" " " 2 Status	0	SUBA,	3(7)	BL	ON	OFF	-	-	-	-	-	
APRELS	Small Probe Release Pulse Status	B,0	BACS,OACS	16(5)	BL	GEN	NGEN	-	-	-	-	-	
APOSMT	Hi Gain Antenna Position Motor Temp	0	SUBB	44	AC	-	-	-	°C	-	-180.0 to +100.0	-	
APOSTQ	Position Torque	0	SUBB,ENG	50,61	AN	-	-	-	FLBS	-	0.35 to 0.0		
APOS1S	Hi Gain Dish Positioner Electronics 1 Pwr Status	0	SUBA	3(4)	BL	ON	OFF	-	-	-	-	-	
APOS2S	" " " " " 2 " "	0	SUBA	3(5)	BL	ON	OFF	-	-	-	-	-	
APULIS	Jet Pulse Width Select Status	B,0	BACS,OACS	13(4)	SD	512ms	128ms	-	-	-	-	-	
ARATEQ	Rate Torque	0	ENG,SUBB	60,43	AN	-	-	-	RPM	-	25.0 to 3 0	-	2 Ranges 7-25 3-7
ARIPAD	Roll Index Delay Magnitude	B,0	BACS,OACS	16(6)-17(7)	SD	-	-	-	DEG	.351	0-359.65		Bit 16(6) = LSB
ASDETS	Spin Rate Detector Status	B,0	BACS,OACS	13(7)	BL	ENAB	INHB	-	-	-	-	-	
ASG*BD	Time From SRR to Gated Star B (Angle)	B,0	N/A	N/A	CALC	-	-	-	DEG			-	
ASG*BZ	Time From SRR to Gated Star B (Magnitude)	B,0	N/A	N/A	CALC	-	-	-	SEC			-	

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MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT =	STATUS "O" BIT =	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
ASIMSZ	Simulated Spin Period Magnitude	B,O	BACS,OACS	20(0)-21(7)	SD	-	-	-	Counts SEC	.25ms	0-65535C 0-16.384S		20(0) = LSB
ASMRSZ	Time From SAR To MRS (Major Frame Pulse)	B,O	N/A	N/A	CALC	-		-	SEC			-	
ASMIPD	Angle From SAR To MIP (Master Index Pulse	B,O	N/A	N/A	CALC	-	-	-	DEG			-	.04/3.6.4.7.2
ASMISZ	Time From SAR to MIS (Minor Frame Rate)	B,O	N/A	N/A	CALC	-	-	-	SEC			-	
ASPAVZ	Averaged Spin Period	B,O	N/A	N/A	CALC	-	-		SEC		4.0-8.85 RPM		
ASPRNS	PLL Spin Range Select	B,O	BACS,OACS	BACS,OACS	SD	-	-	00	RPM	-	8.0-17.0 RPM		
						-	-	10	RPM	-	16.0-35.4 RPM		
						-	-	01	RPM	-	32-70.8 RPM		
						-	-	11	RPM				.04/3.6.4.5.2
ASPINZ	Non-Averaged Spin Period (SAR to SAR)	B,O	N/A	N/A	CALC	-	-	-	SEC			-	
ASRIPD	Angle from SAR to RIP (Roll Index Pulse)	B,O	N/A	N/A	CALC	-	-	-	DEG			-	.04/3.6.4.6.2
ASRRSS	Selected Roll Reference Select Status	B,O	BACS,OACS	15(5-6)	SD	SIM(Simulator) =		10	-	-	-	-	
						*** (Star) =		01	-	-	-	-	
						SUN (Sun) =		11	-	-	-	-	
						SIM (Simulator) =		00	-	-	-	-	
ASS2SD	Time From SAR To SUN2 Pulse (Angle)	B,O	N/A	N/A	CALC	-	-	-	DEG				
ASS2SZ	Time From SAR To SUN2 Pulse (Magnitude)	B,O	N/A	N/A	CALC	-	-	-	SEC				
ASTART	Star Sensor Temp	B,O	BETY	19	AC	-	-	-	DEG C				
			BEING,OENG	62	AC	-	-	-	DEG.C			-	
			BSUBB,OSUBB	18	AC	-	-	-	DEG.C			-	
ASUNGS	Sun Gate Status	B,O	BACS,OACS	16(3)	SD	ENAB	DSAB	-	-	-	-		
ASUNSS	Sun Sensor Select Status	B,O	BACS,OACS	15(3-4)	SD	MIDR(M'drange) =		00	-	-	-	-	
					SD	EXRL(Lower) =		01	-	-	-	-	Extended Range-
					SD	EXRU(Upper) =		10	-	-	-	-	Extended Range
					SD	INV(Test) =		11	-	-		-	
ATTMAZ	Attitude Measurement Magnitude	B,O	BETY	16/17	SD	-	-	-	Counts SEC	0.25 msec	0-65535C 0-16.38S		16(0) = LSB
ATTMZZ			BENG,OLACR,OENG	10/11,42/43			-	-	"	"	"		
			BACS,OACS	8/9,24/25		-	-	-	"	"	"		
				40/41		-	-	-	"	"			
				56/57		-	-	-	"	"	"		
			BSUBB,OSUBB	0/1,32/33		-	-	-	"	"	"		

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT =	STATUS "0" BIT =	STATUS MULT	E V CONVERSION UNIT	E V CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
ATTMSS	Attitude Measurement Selected	B,O	BETY,	18(6)	SD	1	2	-	-		-		
			BENG,OLACR,OENG	12(6),	SD	1	2	-	-	-	-		
				44(6)	SD	1	2	-	-		-		
			BACS,OACS	10(6)	SD	1	2	-	-	-	-		
				26(6),	SD	1	2	-	-	-	-		
				42(6),	SD	1	2	-	-	-	-		
				58(6)	SD	1	2	-	-	-	-		
			OSUBB, [illegible]	2(6),34(6)	SD	1	2	-	-	-	-		
AVP[illegible]	DCE Variable Phase Delay 1 Magnitude ([illegible])	O	OSUBB	27-28(0-1)	SD	-	-	-					27(0) = MSB
AVP[illegible]	DCE Variable Phase Delay 2 Magnitude ([illegible])	O	OSUBB	28(4)-29(7)	SD	-	-	-					28(4) = MSB
A*ACQS	Star Acquisition Status	B,O	BACS,OACS	15(7)	BL	STAR	[illegible]	-	-		-	-	
A*GASS	Star Gate A Channel Select Status	B,O	BACS,OACS	15(1)	BL	ONE	TWO	-	-	-	-	-	
A*GBSS	Star Gate B Channel Select Status			15(2)	BL	ONE	TWO	-	-	-	-	-	
A*1BPS	Star 1 Bandpass Status	B,O	BSUBA,OSUBA	10(0)	BL	TWO	19	-	-	-	-	-	
A*2BPS	Star 2 Bandpass Status	B,O	BSUBA,OSUBA	10(1)	BL	TWO	19	-	-	-	-	-	
A*1BRN	Star 1 Brightness	B,O	BENG	23,	AN	-	-	-	VOLTS	-	0.0 to 5.1		
			BACS,OACS	27,	AN	-	-		VOLTS		"		
			BSUBB,OSUBB	14	AN	-	-	-	VOLTS	-	"		
A*2BRN	Star 2 Brightness	B,O	BENG	55,	AN	-	-	-	VOLTS	-	"		
			BACS,OACS	59,	AN	-	-	-	VOLTS	-	"		
			BSUBB,OSUBB	15,	AN	-	-	-	VOLTS	-	"		
A*1THS	Star 1 Threshold Setting	B,O	BENG	28,	AN	-	-	-	VOLTS	-	0.0 to 5.1		
			BACS,OACS	28,	AN	-	-	-	VOLTS	-	"		
			BSUBB,OSUBB	16	AN	-	-	-	VOLTS	-	"		
A*2THS	Star 2 Threshold Setting	B,O	BENG	36,	AN	-	-	-	VOLTS	-	"		
			BACS,OACS	60,	AN	-	-	-	VOLTS	-	"		
			BSUBB,OSUBB	17	AN	-	-	-	VOLTS	-	"		
A*1PWS	Star 1 Power S[illegible]	B,O	BSUBA,OSUBA	3(4),7(0)	BL	ON	OFF	-	-	-	-	-	
A*2PWS	Star 2 Power [illegible]	B,O	BSUBA,OSUBA	3(5),7(1)	BL	ON	OFF	-	-	-	-	-	

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MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT =	"0"BIT =	MULT	E V CONVERSION UNIT	QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
C1TIMC	Small Probe 1 Coast Timer Verification	B	BSUBC	21-22	SD	-	-	-					21(0) = LSB
C2TIMC	" " 2 " " "	B		37-38	SD	-	-	-					
C3TIMC	" " 3 " " "	B		53-54	SD	-		-					13(1) = MSB
CCMD1C	Command Counter 1	B,O	BENG,OENG,OSUBA,	13(1-6)	SD	-	-	-	CMDS	7 Bit Bin	0-127	-	
			BSUBA		SD	-		-	CMDS	7 Bit Bin	0-127	-	45(1) = MSB
CCMD2C	Command Counter 2	B,O	BENG,OENG	45(1-6)	SD	-	-	-	CMDS	7 Bit Bin	0-127	-	
			BSUBA,OSUBA		SD	-	-	-	CMDS	7 Bit Bin	0-127	-	
CDMD1S	Demodulator 1 Squelch Status	B	BENG,	14(5)	BL	UNSQ	SQLD	-	-	-			
CDMD2S	Demodulator 2 Squelch Status	B	BENG	46(5)	BL	UNSQ	SQLD	-	-				
CLOG1S	Stored Command Logic 1 State	B,O	BENG,OLACR,OENG	14(0-3)	SD	-	-	0000 = SEP0(SEPARATION STATE 0)				-	
			BACS,OACS	30(0-3)	SD	-	-	0001 = TIM0(TIMED START 0)				-	
			BSUBA,OSUBA	14(0-3)	SD	-	-	0010 = STP1 (STOP 1)				-	
						-	-	0011 = STP2 (STOP 2)				-	
						-	-	0100 = SEP1(SEPARATION STATE 1)				-	
						-	-	0101 = TIM1(TIMED START 1)				-	
						-	-	0110 = ADVC(ADVANCE COMPLETE)				-	
						-	-	0111 = INVD (INVALID)				-	
						-	-	1000 = PROC (PROCESS COMMAND)				-	
						-	-	1001 = SUB1(SUBTRACT 1)				-	
						-	-	1010 = READ (READ)				-	
						-	-	1011 = ADV (ADVANCE)				-	
						-	-	1100 = RUN (RUN				-	
						-	-	1101 = LTIM(LOAD TIMER)				-	
						-	-	1110 = LOAD (LOADING)				-	
						-	-	1111 = STBY (STANDBY)				-	
CLOG2S	Stored Command Logic 2 State	B,O	BENG,OLACR,	46(0-3)	SD	-	-					-	
			OENG,			-	-					-	
			BACS,OACS	62(0-3)	SD	-	-	(Same as Above)				-	
			BSUBA,OSUBA	17(0-3)	SD	-	-					-	
CLASWS	Large Probe Acceleration Switch Status	LP	LDESC,LBLKD	3(1)	BL	ACTU	NACT	-	-	-	-	-	
CLTSWS	Large Probe Thermal Switch Status	LP	LDESC,LBLKD	3(2)	BL	ACTU	NACT	-	-		-	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT =	STATUS "0" BIT =	STATUS MULT.	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ.	RANGE	SAMPLE TIME	REMARKS/REF
CMEM1	Command Memory 1 Readout	8,0	BCMRO,OCMRO	9-36	SD	-	-	-	-	-	-	-	
CMEM2	Command Memory 2 Readout	8,0	BCMRO,OCMRO	37-63	SD	-	-	-	-	-	-	-	
CMEM1C	Command Memory 1 Address Pointer	8,0	BCMRO,OCMRO	8(1-7)	SD	-	-	-	CMDS PROCESSED		0-127 CMDS	-	7-Bit Binary
CMEM2C	Command Memory 2 Address Pointer	8,0	BCMRO,OCMRO	36(1-7)	SD	-	-	-	CMDS PROCESSED		0-127 CMDS	-	Counters
CPWR1S	CMD Processor 1 Power Status	8,0	BSUBA,OSUBA	10(5)	BL	ON	OFF	-	-	-	-	-	
CPWR2S	CMD Processor 2 Power Status	8,0	BSUBA,OSUBA	10(6)	BL	ON	OFF	-	-	-	-	-	
CREJ1S	Command Reject 1 Status	8,0	BENG,OENG	13(0)	SD	REJT	ACPT	-	-	-	-	-	Real-Time Cmds.
			BSUBA,OSUBA	13(0)	SD	REJT	ACPT	-	-	-	-	-	
			OLACR	13(0)	SD	REJT	ACPT	-	-	-	-	-	
			BACS,OACS	29(0)	SD	REJT	ACPT	-	-	-	-	-	
CREJ2S	Command Reject 2 Status	8,0	BENG,OENG	45(0)	SD	REJT	ACPT	-	-	-	-	-	Real-Time Cmds
			BSUBA,OSUBA	16(0)	SD	REJT	ACPT	-	-	-	-	-	
			OLACR	45(0)	SD	REJT	ACPT	-	-	-	-	-	
			BACS,OACS	61(0)	SD	REJT	ACPT	-	-	-	-	-	
CREV1S	CMD Processor 1 Receiver Reverse Status	8,0	BSUBA,OSUBA	10(2)	BL	NORM	REV	-	-	-	-	-	
CREV2S	CMD Processor 2 Receiver Reverse Status	8,0	BSUBA,OSUBA	10(3)	BL	NORM	REV	-	-	-	-	-	
CSCL1S	Stored Command Logic 1 Status	8,0	BENG,OENG	14(4)	BL	ON	OFF	-	-	-	-	-	
			BACS,OACS	30(4)	BL	ON	OFF	-	-	-	-	-	
			BSUBA,OSUBA	14(4)	BL	ON	OFF	-	-	-	-	-	
			OLACR	14(4)	BL	ON	OFF	-	-	-	-	-	
CSCL2S	Stored Command Logic 2 Status	8,0	BENG,OENG	46(4)	BL	ON	OFF	-	-	-	-	-	
			BACS,OACS	62(4)	BL	ON	OFF	-	-	-	-	-	
			BSUBA,OSUBA	17(4)	BL	ON	OFF	-	-	-	-	-	
			OLACR	46(4)	BL	ON	OFF	-	-	-	-	-	
CXASWS	Acceleration Switch Status	SP1,2,3	SBLKO	3(2)	BL	ACTU	NACT	-	-	-	-	-	X=SP1,2,&3

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT=	STATUS "0" BIT=	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
[illegible]	Bit Rate	B,O	BETT,	3(4-7)	SD	-	8 BPS	= 0000	-	-	-	-	
			BENG,OENG,		SD	-	16 BPS	= 0001	-	-	-	-	
							32 BPS	= 0010	-	-	-	-	
			BACS,OACS,		SD	-	64 BPS	= 0011	-	-	-	-	
			BCMRO,OCMRO,		SD	-	128 BPS	= 0100	-	-	-	-	
			OPLBA,OPLRB,		SD	-	170 2/3	= 0101	-	-	-	-	
			OPLBC,OPLBD		SD	-	256	= 0110	-	-	-	-	
			OPLBE,OAPSA,		SD	-	341 1/3	= 0111	-	-	-	-	
			OAPSB,OLACA,		SD	-	512	= 1000	-	-	-	-	
			OOMRO,OPRE		SD	-	682 2/3	= 1001	-	-	-	-	
					SD	-	1024	= 1010	-	-	-	-	
					SD	-	2048	= 1011	-	-	-	-	
					SD	-	4096	= 1100,1101,1110,1111			-	-	
		LP	LDESC,LDLKO	3(7)	SD	256	128	-	-	-	-	-	
		SP	SADES,SBLKO,	3(7)	SD	64	16	-	-	-	-	-	
		SP	SLDES	3(7)	SD	64	16	-	-	-	-	-	
DCLOK1	Spacecraft Clock Magnitude	B,O	BCMRO,OCMRO	*	SD	-	-	-	SEC	.125 SEC		-	7(0) = MSB, 2^{23}
DCLOK2	Spacecraft Clock Magnitude	B,O	BENG,OENG	50	SD	-	-	-	SEC	.125 SEC		-	50(0) = MSB, 2^{15}
DCLOK3	Spacecraft Clock Magnitude	B,O	BENG,OENG	51	SD	-	-	-	SEC	.125 SEC			51(0) = MSB, 2^{7}
[illegible]	Spacecraft Clock Magnitude	B,O	BACS,OACS	54	SD	-	-	-	SEC	.125 SEC			54(0) = MSB, 2^{7}
[illegible]	Spacecraft Clock Magnitude	B,O	OSUBA,OSUBA	0-2	SD	-	-	-	SEC	.125 SEC			0(0) = MSB, 2^{23}
[illegible]	Command Data Unit Temp	SP1	SSUBA,	32	SD	-	-	-	°C			-	
[illegible]	" " " "	SP2	SSUBA	32	SD	-	-	-	°C			-	
[illegible]	" " " "	SP3	SSUBA	32	SD	-	-	-	°C			-	
[illegible]	" " " "	LP	LSUBA	58	SD	-	-	-	°C			-	
[illegible]	Lg. Probe Data Storage Status	LP	LDESC,LDLKO	3(0)	BL	STOR	RSTO	-	-	-	-	-	
[illegible]	PCM Encoder 1 Power Status	B,O	OSUBA,OSUBA	4(6)	BL	IDLE	OUTL	-	-	-	-	-	
[illegible]	PCM Encoder 2 Power Status	B,O	OSUBA,OSUBA	4(7)	BL	IDLE	OUTL	-	-	-	-	-	
[illegible]	PCM Encoder 1 Calibrate	B,O	OSUBA,OSUBA	11	SD	-	-	-	VOLTS	-	0 to 5.1	-	
[illegible]	PCM Encoder 2 Calibrate	B,O	OSUBA,OSUBA	12	SD	-	-	-	VOLTS	-	0 to 5.1	-	
[illegible]	Data Storage Unit 1 Power Status	O	[illegible]	8(2)	BL	ON	OFF	-	-	-	-	-	FORMATS APPLY TO
[illegible]	Data Storage Unit 2 Power Status	O	[illegible]	8(3)	BL	ON	OFF	-	-	-	-	-	BOTH DSU STATUS
[illegible]	[illegible]												

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT*	STATUS "0" BIT*	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
DTLMP1S	TLM PROCESSOR 1 Power Status	B,O	BSUBA,OSUBA	6(0)	BL	ON	OFF	*	*	*	*	*	
DTLMP2S	TLM Processor 2 Power Status	B,O	BSUBA,OSUBA	6(1)	BL	ON	OFF	*	*	*	*	*	
DUSTRS	Small Probe(s) Data Storage Status	SP1,2,3	UDES,BLKD,LDES,	3(0)	BL	STOR	NSTO	*	*	*	*	*	
EBIMSS	BIMS Power Status	B	BSUBC	1(0)	BL	ON	OFF	*	*	*	*	*	
EBNMSS	BNMS " "	B	BSUBC	1(1)	BL	ON	OFF	*	*	*	*	*	
ELASS	LAS " "	LP	LSUBA,LSUBB	8(0)	BL	ON	OFF	*	*	*	*	*	
ELCPSS	LCPS " "	LP	LSUBA,LSUBB	8(2)	BL	ON	OFF	*	*	*	*	*	
ELEVTB	Time of HGA Elevation Angle Sample (in UT)	O	N/A	N/A	CALC	ON	OFF	*	HH,MM,SS,T			*	PC-454.04/3.6.4.9.3
ELGCS	LGC Power Status	LP	LSUBA,LSUBB	8(5)	BL	ON	OFF	*	*	*	*	*	
ELIRS	LIR " "	LP	LSUBA,LSUBB	8(3)	BL	ON	OFF	*	*	*	*	*	
ELNMSS	LNMS " "	LP	LSUBA,LSUBB	8(4)	BL	ON	OFF	*	*	*	*	*	
ELNS	LN " "	LP	LSUBA,LSUBB	8(1)	BL	ON	OFF	*	*	*	*	*	
ELSFRS	LSFR " "	LP	LSUBA,LSUBB	8(6)	BL	ON	OFF	*	*	*	*	*	
EOCPPS	OCPP Power Status	O	OSUBD	1(6)	BL	ON	OFF	*	*	*	*	*	
EOEFDS	OEFD " "	O	OSUBD	0(4)	BL	ON	OFF	*	*	*	*	*	
EOETPS	OETP " "	O	OSUBD	1(1)	BL	ON	OFF	*	*	*	*	*	
EOGBSS	OGBS " "	O	OSUBD	0(5)	BL	ON	OFF	*	*	*	*	*	
EOIMSS	OIMS " "	O	OSUBD	1(0)	BL	ON	OFF	*	*	*	*	*	
EOIRSS	OIR Power Status	O	OSUBD	1(7)	BL	ON	OFF	*	*	*	*	*	
EOMAGS	OMAG " "	O	OSUBD	0(7)	BL	ON	OFF	*	*	*	*	*	
EONMSS	ONMS " "	O	OSUBD	1(5)	BL	ON	OFF	*	*	*	*	*	
EOPAS	OPA " "	O	OSUBD	0(3)	BL	ON	OFF	*	*	*	*	*	
EORADS	ORAD " "	O	OSUBD	2(0)	BL	ON	OFF	*	*	*	*	*	
EORPAS	ORPA Power Status	O	OSUBD	0(0)	BL	ON	OFF	*	*	*	*	*	
EOUVSS	OUVS " "	O	OSUBD	1(4)	BL	ON	OFF	*	*	*	*	*	
ESASS	SAS " "	SP1,2,3	SUBA,SUBB,SUBC	56(0)	BL	ON	OFF	*	*	*	*	*	
ESNS	SN " "	SP1,2,3	SUBA,SUBB,SUBC	56(1)	BL	ON	OFF	*	*	*	*	*	
ESNFRS	SNFR " "	SP1,2,3	SUBA,SUBB,SUBC	56(2)	BL	ON	OFF	*	*	*	*	*	

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APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT =	STATUS "0" BIT =	STATUS MULT.	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
FORMAT	Spacecraft Telemetry Format ID	O	OENG	3 (0-3)	SD	ORBITER ENGRG.		0000	-	-	-	-	
		B	BENG	3 (0-3)	SD	BUS ENGRG.		0001	-	-	-	-	
		B	BETY	3 (0-3)	SD	BUS ENTRY		0010	-	-	-	-	
		O	PROGRAMMABLE	3 (0-3)	SD			0011	-	-	-	-	
		O,B	OACS,BACS	3 (0-3)	SD	ACS		0100	-	-	-	-	
		O,B	OCMBO,BCMBO	3 (0-3)	SD	CMD.MEM.READOUT		0101	-	-	-	-	
		O,B	OPBK,BPBK	3 (0-3)	SD	PLAYBACK		0110	-	-	-	-	
		O	ODMBO,BDMBO	3 (0-3)	SD	DATA MEM. READOUT		0111	-	-	-	-	
		O	OLACR	3 (0-3)	SD	LAUNCH/CRUISE		1000	-	-	-	-	
		O	OPERA	3 (0-3)	SD	PERIAPSIS A		1001	-	-	-	-	
		O	OPERB	3 (0-3)	SD	PERIAPSIS B		1010	-	-	-	-	
		O	OPERC	3 (0-3)	SD	PERIAPSIS C		1011	-	-	-	-	
		O	OPERD	3 (0-3)	SD	PERIAPSIS D		1100	-	-	-	-	
		O	OPERE	3 (0-3)	SD	PERIAPSIS E		1101	-	-	-	-	
		O	OAPOA	3 (0-3)	SD	APOAPSIS A		1110	-	-	-	-	
		O	OAPOB	3 (0-3)	SD	APOAPSIS B		1111	-	-	-	-	
		LP	LDESC	3 (5-6)	SD	DESCENT		00	-	-	-	-	
		LP	LBLKO	3 (5-6)	SD	BLACKOUT		11	-	-	-	-	
		SP	SUDES	3 (5-6)	SD	UPPER DESCENT		00	-	-	-	-	
		SP	SBLKO	3 (5-6)	SD	LOWER DESCENT		11	-	-	-	-	
		SP	SLDES	3 (5-6)	SD				-	-	-	-	
DSUCS	DSU Control Status	O	OPERA,OPERB,OPERC	8 (5-7)	SD	STBY(STANDBY)		000	-	-	-	-	
			OPERD,OPERE,OAPOA	8 (5-7)	SD	STBY(STANDBY)		001	-	-	-	-	
			OAPOB,OLACR,ODMBO	8 (5-7)	SD	READ1(READMEM1)		010	-	-	-	-	
			OPBK,OENG	8 (5-7)	SD	READ2(READMEM2)		011	-	-	-	-	
				8 (5-7)	SD	STORE1(STOREMEM1)		100	-	-	-	-	
				8 (5-7)	SD	STORE2(STOREMEM2)		101	-	-	-	-	
				8 (5-7)	SD	STBY-R(STANDBY-RESET)		110	-	-	-	-	
				8 (5-7)	SD	STBY (STANDBY)		111	-	-	-	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT=	STATUS 0 BIT=	STATUS MULT.	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ.	RANGE	SAMPLE TIME	REMARKS/REF
MASUTR	Time of S/C Transmission of 1st Bit of Major Frame	B,O	N/A	N/A	CALC	*	*	*	HH:MM:SS.T		*	*	SCID = 0, IN UT
MIPUTR	Time of S/C Transmission of 1st Bit of Master Index Pulse	B,O	N/A	N/A	CALC	*	*	*	HH:MM:SS.T		*	*	IN UT
MISUTR	Time of S/C Transmission of 1st Bit of Minor Frame	B,O	N/A	N/A	CALC	*	*	*	HH:MM:SS.T		*	*	IN UT
P1BATT	Small Probe 1 Battery Temp	B	BSUBC	28	SD	*	*	*	°C			*	
P2BATT	" " 2 " "	B	BSUBC,BSUBB	44,28	SD	*	*	*	°C			*	
P3BATT	" " 3 " "	B	BSUBC	60	SD	*	*	*	°C			*	
P1BUSI	" " 1 Bus Current	SP	SSUBA,SSUBB,SSUBC	7,23,39,55	SD	*	*	*	AMPS	*	0.0 to 4.0	*	
P2BUSI	" " 2 " "	SP	SSUBA,B,AC	7,23,39,55	SD	*	*	*	AMPS	*	0.0 to 4.0	*	
P3BUSI	Small Probe 3 Bus Current	SP	SSUBA,B,AC	7,23,39,55	SD	*	*	*	AMPS	*	0.0 to 4.0	*	
P1BUSV	" " 1 " Voltage	SP	SSUBA,B,AC	6,22,38,54	SD	*	*	*	VOLTS		0.0 to [illegible]	*	
P2BUSV	" " 2 " "	SP	SSUBA,B,AC	6,22,38,54	SD	*	*	*	VOLTS		0.0 to 33.0	*	
P3BUSV	" " 3 " "	SP	SSUBA,B,AC	6,22,38,54	SD	*	*	*	VOLTS		0.0 to 33.0	*	
P1CD1S	" " 1 CDU and RF Power Relay 1 Status	SP	SSUBA,B,AC	8(2)	BL	ON	OFF	*	*	*	*	*	
P1CD2S	Small Probe 1 CDU and RF Power Relay 2 Status	SP	SSUBA,B,AC	8(3)	BL	ON	OFF	*	*	*	*	*	
P2CD1S	" " 2 " " " " " 1 "	SP	SSUBA,B,AC	8(2)	BL	ON	OFF	*	*	*	*	*	
P2CD2S	" " 2 " " " " " 2 "	SP	SSUBA,B,AC	8(3)	BL	ON	OFF	*	*	*	*	*	
P3CD1S	" " 3 " " " " " 1 "	SP	SSUBA,B,AC	8(2)	BL	ON	OFF	*	*	*	*	*	
P3CD2S	" " 3 " " " " " 2 "	SP	SSUBA,B,AC	8(3)	BL	ON	OFF	*	*	*	*	*	
P1HTRS	Small Probe 1 [illegible] Htr. Relay Status	B	BSUBC	1(4)	BL	ON	OFF	*	*	*	*	*	
P2HTRS	" " 2 " " " "	B	BSUBC	1(5)	BL	ON	OFF	*	*	*	*	*	
P3HTRS	" " 3 " " " "	B	BSUBC	1(6)	BL	ON	OFF	*	*	*	*	*	
P1HTRS	Small Probe 1 Heater Power Status	B	BENG,BSUBC	8(4) 9(4)	BL	ON	OFF	*	*	*	*	*	
P2HTRS	" " 2 " " "	B	BENG,BSUBC	8(5) 9(5)	BL	ON	OFF	*	*	*	*	*	
P3HTRS	" " 3 " " "	B	BENG,BSUBC	8(6) 9(6)	BL	ON	OFF	*	*	*	*	*	
P1WIWS	Small Probe 1 SR Window Htr. Power Status	SP	SSUBA,SUBB,SUBC	8(4)	BL	ON	OFF	*	*	*	*	*	
P2WIWS	" " 2 " " " " "	SP	SSUBA,SUBB,SUBC	8(4)	BL	ON	OFF	*	*	*	*	*	
P3WIWS	" " 3 " " " " "	SP	SSUBA,SUBB,SUBC	8(6)	BL	ON	OFF	*	*	*	*	*	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT=	STATUS "0"BIT=	STATUS MULT	E.U. CONVERSION UNIT	E.U. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
P1PR1S	Small Probe 1 Internal Power Relay 1 Status	B	BSUBC	2(0)	BL	ON	OFF	-	-	-	-	-	
P1PR2S	" " 1 " " " 2 "	B	BSUBC	2(1)	BL	ON	OFF	-	-	-	-	-	
P2PR1S	" " 2 " " " 1 "	B	BSUBC	2(2)	BL	ON	OFF	-	-	-	-	-	
P2PR2S	" " 2 " " " 2 "	B	BSUBC	2(3)	BL	ON	OFF	-	-	-	-	-	
P3PR1S	" " 3 " " " 1 "	B	BSUBC	2(4)	BL	ON	OFF	-	-	-	-	-	
P3PR2S	" " 3 " " " 2 "	B	BSUBC	2(5)	BL	ON	OFF	-	-	-	-	-	
P1SP1S	Small Probe 1 Science Power Relay 1 Status	SP	SSUBA, B, & C	8(5)	BL	ON	OFF	-	-	-	-	-	
P1SP2S	" " 1 " " " 2 "	SP	SSUBA, B, & C	8(6)	BL	ON	OFF	-	-	-	-	-	
P2SP1S	" " 2 " " " 1 "	SP	SSUBA, B, & C	8(5)	BL	ON	OFF	-	-	-	-	-	
P2SP2S	" " 2 " " " 2 "	SP	SSUBA, B, & C	8(6)	BL	ON	OFF	-	-	-	-	-	
P3SP1S	" " 3 " " " 1 "	SP	SSUBA, B, & C	8(5)	BL	ON	OFF	-	-	-	-	-	
P3SP2S	" " 3 " " " 2 "	SP	SSUBA, B, & C	8(6)	BL	ON	OFF	-	-	-	-	-	
PB1P1T	Battery 1, Pack 1 Temp	B	BENG,BSUBA	56 55	AC	-	-	-	°C	-	30.0 to 0.0	-	
PB2P1T	" 2 " 1 "	B	BENG,BSUBA	57 57	AC	-	-	-	°C	-	"	-	
PB1P2T	" 1 " 2 "	B	BENG,BSUBA	58 58	AC	-	-	-	°C	-	"	-	
PB2P2T	" 2 " 2 "	B	BENG,BSUBA	59 59	AC	-	-	-	°C	-	"	-	
PB1R1S	Battery 1 Relay 1 Status	B	BSUBA	4(0)	BL	HI	LO	-	-	-	-	-	
PB1R2S	" 1 " 2 "	B	BSUBA	4(1)	BL	HI	LO	-	-	-	-	-	
PB2R1S	" 2 " 1 "	B	BSUBA	4(3)	BL	HI	LO	-	-	-	-	-	
PB2R2S	" 2 " 2 "	B	BSUBA	4(4)	BL	HI	LO	-	-	-	-	-	
PBAT1V	Battery 1 Terminal Voltage	B,O	BENG,OLACR	22	AN	-	-	-	VOLTS	-	0.0 to 40.0	-	
		O	OENG.	22	AN	-	-	-	VOLTS	-	0.0 to 40.0	-	
		B,O	BSUBA,OSUBA	49	AN	-	-	-	VOLTS	-	"	-	
PBAT2V	Battery 2 Terminal Voltage	B,O	BENG,OLACR	54	AN	-	-	-	VOLTS	-	"	-	
		O	OENG	54	AN	-	-	-	VOLTS	-	"	-	
		B,O	BSUBA,OSUBA	62	AN	-	-	-	VOLTS	-	"	-	
[illegible]	Spacecraft Loads Current	B	BETY	63	AN	-	-	-	AMPS	-	0.0 to 18.0	-	
		B,O	BENG,OENG,OLACR	18	AN	-	-	-	AMPS	-	"	-	
		B,O	BACS,OACS	23&55	AN	-	-	-	AMPS	-	"	-	
		B,O	BSUBA,OSUBA	61	AN	-	-	-	AMPS	-	"	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS '1' BIT=	STATUS '0' BIT=	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
PCHEKS	Probe Checkout Bus Status	B	BSUBC	3	BL	ON	OFF	-	-	-	-	-	
PCHG1I	Battery 1 Charge Current	B,O	BENG,OLACR,OENG	20	AN	-	-	-	AMPS	-	0.0 to 1.0	-	
		B,O	BSUBA,OSUBA	47	AN	-	-	-	AMPS	-	0.0 to 1.0	-	
PCHG2I	Battery 2 Charge Current	B,O	BENG,OLACR,OENG	52	AN	-	-	-	AMPS	-	0.0 to 1.0	-	
		B,O	BSUBA,OSUBA	50	AN	-	-	-	AMPS	-	0.0 to 1.0	-	
PDIS1I	Battery 1 Discharge Current	B,O	BENG,OLACR,OENG	21	AN	-	-	-	AMPS	-	0.0 to 12.0	-	
		B,O	BSUBA,OSUBA	48	AN	-	-	-	AMPS	-	0.0 to 12.0	-	
PDIS2I	Battery 2 Discharge Current	B,O	BENG,OLACR,OENG	53	AN	-	-	-	AMPS		0.0 to 12.0	-	
		B,O	BSUBA,OSUBA	61	AN	-	-	-	AMPS		0.0 to 12.0	-	
PEBUSV	Essential Bus Voltage	B	BETY	62	AN	-	-	-	VOLTS	-	0.0 to 32.0	-	
		B,O	BENG,OLACR,OENG	16 & 48	AN	-	-	-	VOLTS	-	"	-	
		B,O	BACS,OACS	22	AN	-	-	-	VOLTS	-	"	-	
		B,O	BSUBA,OSUBA	31 & 63	AN	-	-	-	VOLTS	-	"	-	
PHT1HS	OIM Heater 1 Power Status	O	OSUBA	6(6)	BL	ON	OFF	-	-	-	-	-	
PHT2HS	OIM Heater 2 Power Status	O	OSUBA	6(7)	BL	ON	OFF	-	-	-	-	-	
PHTAJS	AFT Axial Jet Heaters Power Status	B	BSUBA	6(4)	BL	ON	OFF	-	-	-	-	-	
PHTFJS	Forward Axial Jet Heaters Power Status	B	BSUBA	6(5)	BL	ON	OFF	-	-	-	-	-	
PHTJ1S	Forward Jets 1 & 2 Heater Status	O	OSUBA	6(4)	BL	ON	OFF	-	-	-	-	-	
PHTJ3S	AFT Jets 3 & 4 Heater Status	O	OSUBA	6(5)	BL	ON	OFF	-	-	-	-	-	
PHTTHS	Propellant Tank Heaters Select Status	B,O	BENG,OENG	9(6)	BL	PRIM	SECD	-	-			-	
		B,O	BSUBA,OSUBA	9(6)	BL	PRIM	SECD	-	-		-	-	
PLBATT	Large Probe Battery Temp	B	BSUBC	44	AC	-	-	-	°C			-	
		B	BSUBC	12	AC	-	-	-	°C			-	
PLBUSI	Large Probe Bus Current	LP	LSUBA,LSUBB	7, 23	AN	-	-	-	AMPS	-	0.0 to 15.0	-	
		LP	LSUBA,LSUBB	39, 55	AN	-	-	-	AMPS	-	0.0 to 15.0	-	
PLBUSV	Large Probe Bus Voltage	LP	LSUBA,LSUBB	6, 22	AN	-	-	-	VOLTS	-	0.0 to 33.0	-	
		LP	LSUBA,LSUBB	38, 54	AN	-	-	-	VOLTS	-	0.0 to 33.0	-	
PLCD1S	Lg. Pr. CDU Power Relay 1 Status	LP	LSUBA,LSUBB	0(2)	BL	ON	OFF	-	-	-	-	-	
PLCD2S	Lg. Pr. CDU Power Relay 2 Status	LP	LSUBA,LSUBB	0(3)	BL	ON	OFF	-	-	-	-	-	
PLBRHS	Switched Loads Bus Protection Relay Status	B,O	BSUBA,OSUBA	8(7)	BL	ON	OFF	-	-	-	-	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT	STATUS "0" BIT	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
PLHT1S	LIR Window Heater 1st Stage Status	LP	LSUBA,LSUBB	0(4)	BL	ON	OFF	-	-	-	-	-	
PLHT2S	LIR Window Heater 2nd Stage Status	LP	LSUBA,LSUBB	9(5)	BL	ON	OFF	-	-	-	-	-	
PLHTBS	Large Probe Battery Heater Relay Status	B	BSUBC	1(7)	BL	ON	OFF	-	-	-	-	-	
PLHTRS	Large Probe Heater Power Status	B	BENG	8(7)	BL	ON	OFF	-	-	-	-	-	
		B	BSUBC	9(7)	BL	ON	OFF	-	-	-	-	-	
PLHTWS	Large Probe Window and Prism Heaters Power Status	LP	LSUBA,LSUBB	16(6)	BL	ON	OFF	-	-	-	-	-	
PLLMTI	Bus Voltage Limiter Current	B,O	BENG,OLACR,OENG	19	AN	-	-	-	AMPS	-	0.0 to 12.0	-	
		B	BSUBA,OSUBA	60	AN	-	-	-	AMPS	-	0.0 to 12.0	-	
PLIM1S	Bus Limiter 1 Enable Status	B,O	BSUBA,OSUBA	8(9)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM2S	" " 2 " "	B,O	BSUBA,OSUBA	8(1)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM3S	" " 3 " "	B,O	BSUBA,OSUBA	8(2)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM4S	" " 4 " "	B,O	BSUBA,OSUBA	8(3)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM5S	" " 5 " "	B,O	BSUBA,OSUBA	8(4)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM6S	" " 6 " "	O	OSUBA	2(5)	BL	ENAB	DSAB	-	-	-	-	-	
PLIM7S	" " 7 " "	O	OSUBA	8(6)	BL	ENAB	DSAB	-	-	-	-	-	
PLPR1S	Large Probe Internal Power Relay 1 Status	B	BSUBC	2(6)	BL	ON	OFF	-	-	-	-	-	
PLPR2S	Large Probe Internal Power Relay 2 Status	B	BSUBC	2(7)	BL	ON	OFF	-	-	-	-	-	
PLRCVS	Large Probe Receiver Power Status	LP	LSUBA,LSUBB	16(7)	BL	ON	OFF	-	-	-	-	-	
PLRFRS	Large Probe RF Power Relay Status	LP	LSUBA,LSUBB	16(3)	BL	ON	OFF	-	-	-	-	-	
PLSP1S	Large Probe Science Power Relay 1 Status	LP	LSUBA,LSUBB	16(4)	BL	ON	OFF	-	-	-	-	-	
PLSP2S	Large Probe Science Power Relay 2 Status	LP	LSUBA,LSUBB	16(5)	BL	ON	OFF	-	-	-	-	-	
PPAN1T	Solar Panel 1 Temp	B	BETY.	45	AC	-	-	-	°C	-	-85 to +100	-	
		B,O	BSUBA,OSUBA	53	AC	-	-	-	°C	-	"	-	
PPAN2T	Solar Panel 2 Temp	B,O	BSUBA,OSUBA	54	AC	-	-	-	°C	-	"	-	
		O	OENG	58	AC	-	-	-	°C	-	"	-	
PPANLI	Solar Panel Current	B,O	BENG,OLACR,OENG	17	AN	-	-	-	AMPS	-	0.0 to 18.0	-	
		B,O	BACS,OACS	43	AN	-	-	-	AMPS	-	"	-	
		B,O	BSUBA,OSUBA	62	AN	-	-	-	AMPS	-	"	-	
PRCHGS	Precharge Status	B,O	BSUBA,OSUBA	10(4)	BL	ON	OFF	-	-	-	-	-	

APPENDIX B: TELEMETRY REFERENCE DATA
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MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS			E.V. CONVERSION		RANGE	SAMPLE TIME	REMARKS/REF
						1BIT =	"0"BIT =	MULT.	UNIT	QUANTIZ.			
PREG1S	Discharge Regulator 1 Select Status	B,O	BSUBA,OSUBA	4(2)	BL	PRI	RED	-	-	-	-	-	
PREG2S	Discharge Regulator 2 Select Status	B,O	BSUBA,OSUBA	4(5)	BL	PRI	RED	-	-	-	-	-	
PREBUS	RF Xmtr. Bus Reset Relay Status	B,O	BSUBA,OSUBA	7(3)	BL	ON	OFF	-	-	-	-	-	
PSCBUS	Science Bus Reset Relay Status	B,O	BSUBA,OSUBA	7(2)	BL	ON	OFF	-	-	-	-	-	
PSCICI	Science Current	B,O	BENG,OLACR,OENG	49	AN	-	-	-	AMPS	-	0.0 to 4.7	-	
		B	BSUBA,OSUBA	58	AN	-	-	-	AMPS	-	0.0 to 1.8	-	
PSPROS	Power System Protection Status	B,O	BENG,OENG	9(7)	BL	ON	OFF	-	-	-	-	-	
		B,O	BSUBA,OSUBA	5(7) 9(0)	BL	ON	OFF	-	-	-	-	-	
PVBIDO	Spacecraft ID	B,O	BCTY,OPERA	4(0-1)	SD		BUS =	00	-	-	-	-	
			BENG,OPERB	4(0-1)	SD		ORBITER =	01	-	-	-	-	
			BACS,OPERC	4(0-1)	SD				-	-	-	-	
			BCMRD,OPERD	4(0-1)	SD				-	-	-	-	
			PROG. OPERE	4(0-1)	SD				-	-	-	-	
			OAPOA	4(0-1)	SD				-	-	-	-	
			OAPOB	4(0-1)	SD				-	-	-	-	
			OLACR	4(0-1)	SD				-	-	-	-	
			OLHRD	4(0-1)	SD				-	-	-	-	
			OOMRD	4(0-1)	SD				-	-	-	-	
			OPBK	4(0-1)	SD				-	-	-	-	
			OENG	4(0-1)	SD				-	-	-	-	
			OACS	4(0-1)	SD				-	-	-	-	
PVBIDO	Spacecraft ID	PROBES	LDESC,SUDES	3(3-4)	SD	SMALL	PROBE 1	= 00	-	-	-	-	
			LBLKD,SBLKD	3(3-4)	SD	SMALL	PROBE 2	= 01	-	-	-	-	
			SLDES	3(3-4)	SD	SMALL	PROBE 3	= 10	-	-	-	-	
					SD	LARGE	PROBE	= 11	-	-	-	-	
PVSCID	Subcommutator ID (Minor Frame Count)	B,O	Same as B,O, above	4(2-7)	SD	-	-	-	COUNTS	BIT 7 = LSB	0 - 63	-	Binary Counter
		PROBES	Same as above	4(4&7)	SD	-	-	-	COUNTS	BIT 7 = LSB	0 - 15	-	Binary Counter
R1WTOV	Stable Oscillator Heater Voltage (SM. Probe 1)	PROBES	SSUBA,SSUBB,SSUBC	15,31,47		-	-	-	VOLTS	-	0.0 to +5.1	-	
R2WTOV	" " " " (SM. Probe 2)			63		-	-	-	VOLTS	-	0.0 to +5.1	-	
R3WTOV	" " " " (SM. Probe 3)					-	-	-	VOLTS	-		-	

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MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1"BIT	STATUS "0"BIT	STATUS MULT.	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ.	RANGE	SAMPLE TIME	REMARKS/REF
R1OSCS	Stable Oscillator Power Status, Sm. Probe 1	SP	SUBA, B, & C	8(7)	BL	ON	OFF	-	-	-	-	-	
R2OSCS	" " " " Sm. Probe 2	SP	SUBA, B, & C	8(7)	BL	ON	OFF	-	-	-	-	-	
R3OSCS	" " " " Sm. Probe 3	SP	SUBA, B, & C	8(7)	BL	ON	OFF	-	-	-	-	-	
RAGC1V	Receiver 1 AGC Voltage	B,O	BETY,OLACR	29	AN	-	-	-	dBm	-	-157 to -70	-	
		B,O	BENG,OENG	29	AN	-	-	-	"	-	"	-	
		B,O	BACS,OACS	7	AN	-	-	-	"	-	"	-	
		B,O	BSUBA,OSUBA	23	AN	-	-	-	"	-	"	-	
RAGC2V	Receiver 2 AGC Voltage	B,O	BETH,OLACR	30	AN	-	-	-	"	-	"	-	
		B,O	BENG,OENG	30	AN	-	-	-	"	-	"	-	
		B,O	BACS,OACS	39	AN	-	-	-	"	-	"	-	
		B,O	BSUBA,OSUBA	24	AN	-	-	-	"	-	"	-	
RAMP1S	Amplifier 1/2 Power Status	B,O	BSUBA,OSUBA	9(3)	BL	A1LA2H	A2LA1H	-	-	-	-	-	
RAMP2S	Amplifier 3/4 Switch Position Status	B,O	BSUBA,OSUBA	9(4)	BL	3	4	-	-	-	-	-	
RAMP1T	RF Power Amplifier 1 Temp.	B,O	BSUBA,OSUBA	27	AC	-	-	-	°C	-	-185.0 to +100.0	-	
RAMP2T	" " " 2 "	B,O	BSUBA,OSUBA	28	AC	-	-	-	°C	-	"	-	
RAMP3T	" " " 3 "	B,O	OSUBA,OSUBA	29	AC	-	-	-	°C	-	"	-	
RAMP4T	" " " 4 "	B,O	BSUBA,OSUBA	30	AC	-	-	-	°C	-	"	-	
RAMP1W	RF Power Amplifier 1 Output	B,O	BENG,OLACR,OENG	24	AN	-	-	-	WATTS	-	0.0 to 11.5	-	
		B,O	BSUBA,OSUBA	33	AN	-	-	-	"	-	"	-	
RAMP2W	" " " 2 "	B,O	BENG,OLACR,OENG	25	AN	-	-	-	"	-	0.0 to 11.8	-	
		B,O	BSUBA,OSUBA	34	AN	-	-	-	"	-	"	-	
RAMP3W	" " " 3 "	B,O	BENG,OLACR,OENG	26	AN	-	-	-	"	-	0.0 to 10.4	-	
		B,O	BSUBA,OSUBA	35	AN	-	-	-	"	-	"	-	
RAMP4W	" " 4 "	B,O	BENG,OLACR,OENG	27	AN	-	-	-	"	-	0.0 to 12.0	-	
		B,O	BSUBA,OSUBA	36	AN	-	-	-	"	-	"	-	
RANT1S	Fwd. Horn/Aft OMNI Power Switch Status	B	BSUBA	9(6)	BL	LFHA	LAHF	-	-	-	-	-	
RANT1S	Aft OMNI/BAPTA Power Switch Status	O	OSUBA	9(6)	BL	HALB	LAHB	-	-	-	-	-	
RANT2S	Horn/Fwd. OMNI Switch Position Status	B	BSUBA	9(5)	BL	OMNI	HORN	-	-	-	-	-	
RANT2S	Hi Gain Dish/Lo Gain Ant. Switch Position Status	O	OSUBA	9(7)	BL	HGDH	LGDH	-	-	-	-	-	
RANT3S	Hi Gain Backup/Fwd. OMNI Switch Position Status	O	OSUBA	9(5)	BL	HGBU	FWOM	-	-	-	-	-	

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APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT =	"0" BIT =	MULT	E.V. CONVERSION UNIT	QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
RCOH1S	Exciter 1 Coherent Mode Status	B,O	BENG,OENG	9(2)	BL	INHB	REST	-	-	-	-	*	
		B,O	BSUBA,OSUBA	5(2)	BL	INHB	REST	-	-	-	-	*	
RCOH2S	Exciter 2 Coherent Mode Status	B,O	BENG,OENG	9(3)	BL	[illegible]	REST	-	-	-	-	*	
		B,O	BSUBA,OSUBA	5(3)	BL	INH_	REST	-	-	-	-	*	
RLAGCV	Receiver AGC Voltage	LP	LSUBA,LSUBB	14,30,	AN	-	-	-	dBm	-	-154 to -70	*	
				46,62	AN	-	-	-	dBm	-	-154 to -70	*	
RLOK1S	Receiver 1 Phase Lock Status	B,O	BENG,OENG	9(0)	BL	INLK	OUTL	-	-	-		*	
		B,O	BSUBA,OSUBA	5(0)	BL	INLK	OUTL	-	-		-	*	
RLOK2S	Receiver 2 Phase Lock Status	B,O	BENG,OENG	9(1)	BL	INLK	OUTL	-	-	-	-	*	
		B,O	BSUBA,OSUBA	5(1)	BL	INLK	OUTL	-	-	-	-	*	
RLOSCT	Transmitter Aux. Oscillator Temp	LP	LSUBA,LSUBB	29	AC	-	-	-	°C	-	-30.0 to +80.0	*	
RLSPEV	Receiver Static Phase Error	LP	LSUBA,LSUBB	13	AN	-	-	-	KHZ	-	±200.0	*	
RLVCOT	Receiver VCO Temp	LP	LSUBA,LSUBB	2	AC	-	-	-	°C	-	-30.0 to +80.0	*	
ROSC1T	Xmtr. Aux. Oscillator 1 Temp	B,O	BENG,OENG	40	AC	-	-	-	°C	-	-30.0 to +80.0	*	
		B,O	BSUBA,OSUBA	21	AC	-	-	-	°C	-	-30.0 to +80.0	*	
ROSC2T	Xmtr. Aux. Oscillator 2 Temp	B,O	BENG,OENG	41	AC	-	-	-	°C	-	-30.0 to +80.0	*	
		B,O	BSUBA,OSUBB	22	AC	-	-	-	°C	-	-30.0 to +80.0	*	
RRCVRS	Receiver Switch Position Status	B,O	BSUBA,OSUBA	9(1)	BL	F2A1	F1A2	-	-	-	-	*	
RREV1C	Receiver 1 Reverse Timer	B,O	BENG,OENG,OLACR	14(6-7)	SD	(WHEN BIT 6=1=15.2 HRS)			(WHEN BIT 7=1=9.1 HRS)			*	MSB BITS
		B,O	BACS,OACS	30(6-7)	SD		*			*		*	" "
		B,O	BSUBA,OSUBA	14(6-7)	SD		*			*		*	" "
RREV2C	Receiver 2 Reverse Timer	B,O	BENG,OENG,OLACR	46(6-7)	SD		*			*		*	" "
		B,O	BACS,OACS	62(6-7)	SD		*			*		*	" "
		B,O	BSUBA,OSUBA	[illegible](6-7)	SD		*			*		*	" "
RSPE1V	Receiver 1 Static Phase Error Voltage	B,O	BENG,OENG,OLACR	37	AN	-	-	-	KHZ	-	±200.0	*	
		B,O	BSUBA,OSUBA	25	AN	-	-	-	KHZ	-	±200.0	*	
RSPE2V	Receiver 2 Static Phase Error Voltage	B,O	BENG,OENG,OLACR	38	AN	-	-	-	KHZ	-	±200.0	*	
		B,O	BSUBA,OSUBA	26	AN	-	-	-	KHZ	-	±200.0	*	
RWCO1S	Exciter 1 Transfer Select Status	B,O	BSUBA,OSUBA	6(2)	BL	VCO	RCVR	-	-	-	-	*	
RWCO2S	Exciter 2 Transfer Select Status	B,O	BSUBA,OSUBA	6(3)	BL	VCO	RCVR		-	-	-	*	

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MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	B" /US			E.V. CONVERSION		RANGE	SAMPLE TIME	REMARKS/REF
						1BIT=	"0"BIT=	MULT.	UNIT	QUANTIZ.			
RVCO1T	Receiver 1 VCO Temp	B,O	BENG,OENG	31	AC	-	-	-	°C	-	-30 to +80	-	
		B,O	BSUBA,OSUBA	19	AC	-	-	-	°C	-	-30 to +80	-	
RVCO2T	Receiver 2 VCO Temp	B,O	BENG,OENG	39	AC	-	-	-	°C	-	-30 to +80	-	
		B,O	BSUBA,OSUBA	20	AC	-	-	-	°C	-	-30 to +80	-	
RXCT1S	Exciter 1 Power Status	B,O	BENG,OENG	9(4)	BL	ON	OFF	-	-	-	-	-	
		B,O	BSUBA,OSUBA	5(4)	BL	ON	OFF	-	-	-	-	-	
RXCT2S	Exciter 2 Power Status	B,O	BENG,OENG	9(5)	BL	ON	OFF	-	-	-	-	-	
		B,O	BSUBA,OSUBA	5(5)	BL	ON	OFF	-	-	-	-	-	
RXCTRS	Exciter Switch Position Status	B,O	BSUBA,OSUBA	9(2)	BL	1	2	-	-	-	-	-	
RXMTRT	X-Band Transmitter Temp	O	OENG,	36		-	-	-	°C	-	3.0 to 50.0	-	
		O	OSUBA	32		-	-	-	°C	-	3.0 to 50.0	-	
RXMTRW	X-Band Transmitter RF Output	O	OENG	28		-	-	-	WATTS		0.0 to 12.5	-	
		O	OSUBA	32		-	-	-	WATTS		0.0 to 12.5	-	
S1AF1T	Small Probe 1 Aft Shelf Temp	B	BENG	61	AC	-		-	°C			-	From Bus
		B	BSUBA	41	AC	-	-	-	°C			-	
		B	BSUBC	79	AC	-	-	-	°C			-	
S1AF2T	Small Probe 1 Aft Shelf Temp	SP	SSUBA, B & C	13,45	AC	-	-	-	°C			-	From Probes
		SP	SSUBC	24	AC	-	-	-	°C			-	
S1ASBS	Small Probe 1 SAS Boom Deploy Status	SP	SSUBA, 9, & C	8(U)	BL	DEPL	STOW	-	-	-	-	-	
S1FBRS	Small Probe 1 SHFB Boom Deploy Status	SP	SSUBA, B, & C	0(1)	BL	DEPL	STOW	-	-	-	-	-	
S1FW1T	Small Probe 1 Forward Shelf Temp	B	BSUBA	44	AC	-	-	-	°C			-	
		B	BSUBC	30	AC	-	-	-	°C			-	
S1FW2T	Small Probe 1 Forward Shelf Temp	SP	SSUBA	29,61	AC	-	-	-	°C			-	
		SP	SSUBB	21,53	AC	-	-	-	°C			-	
		SP	SSUBC	29,40,61	AC	-	-	-	°C			-	
S1INTP	Small Probe 1 Internal Pressure	SP	SSUBA,SSUBB	14,30,	AN	-	-	-	PSI			-	
		SP	SSUBA,SSUBB	46,61	AN	-	-	-	PSI			-	
		SP	SSUBC	2,14,18	AN	-	-	-	PSI			-	
		SP	SSUBC	30,34,46	AN	-	-	-	PSI			-	
		SP	SSUBC	50,62	AN	-	-	-	PSI			-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS "1" BIT	STATUS "0" BIT	STATUS MULT.	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ.	RANGE	SAMPLE TIME	REMARKS/REF
S1RELS	Small Probe 1 Release Status	B	BENG	8(0)	BL	STOW	RELS	-	-	-	-	-	
		B	BSUBC	0(0)	BL	STOW	RELS	-	-	-	-	-	
S2AF1T	Small Probe 2 Aft Shelf Temp	B	BSUBA	24	AC	-	-	-	°C			-	FROM BUS
		B	BSUBC	45	AC	-	-	-	°C			-	
S2AF2T	Small Probe 2 Aft Shelf Temp	SP	SSUBA, B, & C	13,45	AC	-	-	-	°C			-	FROM PROBE
		SP	SSUBC	24	AC	-	-	-	°C			-	
S2ASBS	Small Probe 2 SAS Boom Deploy Status	SP	SSUBA, B, & C	8(0)	BL	DEPL	STOW	-	-	-	-	-	
S2FRBS	Small Probe 2 SNFR Boom Deploy Status	SP	SSUBA, B, & C	8(1)	BL	DEPL	STOW	-	-	-	-	-	
S2FW1T	Small Probe 2 Forward Shelf Temp	B	BSUBA	20	AC	-	-	-	°C			-	
		B	BSUBC	46	AC	-	-	-	°C			-	
S2FW2T	Small Probe 2 Forward Shelf Temp	SP	SSUBA	29,61	AC	-	-	-	°C			-	
		SP	SSUBB	21,53	AC	-	-	-	°C			-	
		SP	SSUBC	29,40,61	AC	-	-	-	°C			-	
S2INTP	Small Probe 2 Internal Pressure	SP	SSUBA,SSUBB	14,30	AN	-	-	-	PSI			-	
		SP	SSUBA,SSUBB	46,61	AN	-	-	-	PSI			-	
		SP	SSUBC	2,14,18	AN	-	-	-	PSI			-	
		SP	SSUBC	30,34,48	AN	-	-	-	PSI			-	
		SP	SSUBC	50,62	AN	-	-	-	PSI			-	
S2RELS	Small Probe 2 Release Status	B	BENG	8(1)	BL	STOW	RELS	-	-	-	-	-	
		B	BSUBC	0(1)	BL	STOW	RELS	-	-	-	-	-	
S3AF1T	Small Probe 3 Aft Shelf Temp	B	BSUBC	61	AC	-	-	-	°C			-	
S3AF2T	Small Probe 3 Aft Shelf Temp	SP	SSUBA, B, & C	13,45	AC	-	-	-	°C			-	
		SP	SSUBC	24	AC	-	-	-	°C			-	
S3ASBS	Small Probe 3 SAS Boom Deploy Status	SP	SSUBA, B, & C	8(0)	BL	DEPL	STOW	-	-	-	-	-	
S3FRBS	Small Probe 3 SNFR Boom Deploy Status	SP	SSUBA, B, & C	8(1)	BL	DEPL	STOW	-	-	-	-	-	
S3FW1T	Small Probe 3 Forward Shelf Temp	B	BSUBA	62	AC	-	-	-	°C			-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS 1BIT-	STATUS "O"BIT-	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
S3FW2T	Small Probe 3 Forward Shelf Temp	SP	SSUBA	29,61	AC	-	-	-	°C			-	
		SP	SSUBB	21,53	AC	-	-	-	°C			-	
		S.	SSUBC	29,40,61	AC	-	-	-	C			-	
S3INTP	Small Probe 3 Internal Pressure	SP	SSUBA,SSUBB	14,30	AN	-	-	-	PSI			-	
		SP	SSUBA,SSUBB	46,61	AN	-	-	-	PSI			-	
		SP	SSUBC	2,14,18	AN	-	-	-	PSI			-	
		SP	SSUBC	30,34,46	AN	-	-	-	PSI			-	
		SP	SSUBC	50,62	AN	-	-	-	PSI			-	
S3RELS	Small Probe 3 Release Status	B	BENG	8(2)	BL	STOW	RELS	-	-	-	-	-	
		B	BSUBC	0(2)	BL	STOW	RELS	-	-	-	-	-	
SBIMST	BIMS Temp	B	BSUBA	43	AC	-	-	-	°C			-	
		B	BSUBC	40	AC	-	-	-	°C			-	
SBNMST	BNMS Temp	B	BSUBA	40	AC	-	-	-	°C			-	
		B	BUSBC	8	AC	-	-	-	°C			-	
SBOOMS	Magnetometer Boom Deploy Status	O	OSUBA	7(6)	BL	DEPL	STOW	-	-	-	-	-	
SHLØ1T	Shelf Temperature 1	B,O	BSUBB,OSUBB	52	AC	-	-	-	°C	-	-70.0 to +130.0	-	
SHLØ2T	" " 2	B,O	"	53	AC	-	-	-	°C	-	"	-	
SHLØ3T	" " 3	B,O	"	54	AC	-	-	-	°C	-	"	-	
SHLØ4T	" " 4	B,O	"	55	AC	-	-	-	°C	-	"	-	
SHLØ5T	" " 5	B,O	"	56	AC	-	-	-	°C	-	"	-	
SHLØ6T	" " 6	B,O	"	57	AC	-	-	-	°C	-	"	-	
SHLØ7T	" " 7	B,O	"	58	AC	-	-	-	°C	-	"	-	
SHLØ8T	" " 8	B,O	"	59	C	-	-	-	°C	-	"	-	
SHLØ9T	" " 9	B,O	"	[illegible]	AC	-	-	-	°C	-	"	-	
SHL1ØT	" " 10	B,O	"	[illegible]	AC	-	-	-	°C	-	"	-	
SHL11T	" " 11	B,O	"	[illegible]	AC	-	-	-	°C	-	"	-	
SHL12T	" " 12	B,O	"	[illegible]	AC	-	-	-	°C	-	"	-	
SIMUTR	Time of S/C Change to Simulated SRR	B,O	N/A	N/A	CALC	CALCULATED					-	-	IN UT
									-	-	-	-	
									-	-	-	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS			E.V. CONVERSION		RANGE	SAMPLE TIME	REMARKS/REF
						1BIT =	"0"BIT =	MULT	UNIT	QUANTIZ			
SLAF1T	Large Probe Aft Shelf Temp	B	BSUBA	39	AC	-	-	-	°C			-	
		B	BSUBC	13	AC	-	-	-	°C				
SLAF2T	Large Probe Aft Shelf Temp	LP	LSUBA,LSUBB	45	AC	-	-	-	°C			-	
SLFW1T	Large Probe Forward Shelf Temp	B	BENG	60	AC	-	-	-	°C			-	
		B	BSUBA	25	AC	-	-	-	°C			-	
		B	BSUBC	14	AC	-	-	-	°C			-	
SLFW2T	Large Probe Forward Shelf Temp	LP	LSUBA,LSUBB	53	AC	-	-	-	°C			-	
SLINTP	Large Probe Internal Pressure	LP	LSUBA,LSU B	15,31	AH	-	-	-	PSI			-	
		LP	LSUBA,LSUBB	47,63	AH	-	-	-	PSI			-	
SLIRWT	LIR Window Temp	LP	LSUBA,LSUBB	61	AC	-	-	-				-	
SLRELS	Large Probe Release Status	B	BENG	8(3)	BL	STOW	RELS	-	-	-	-	-	
		B	BSUBC	0(3)	BL	STOW	RELS	-	-	-	-	-	
SOETPT	OETP Temp	O	OSUBA	41	AC	-	-	-	°C	-	-70.0 to +130.0	-	
SOIUST	OIUS Temp	O	OSUBA	40	AC	-	-	-	°C	-	"	-	
SOMUST	OMUS Temp	O	OSUBA	42	AC	-	-	-	°C	-	"	-	
SOPAIT	OPA Temp	O	OSUBA	43	AC	-	-	-	°C	-	"	-	
SORADT	ORAD Temp	O	OSUBA	44	AC	-	-	-	°C	-	"	-	
SORPAT	ORPA Temp	O	OSUBA	39	AC	-	-	-	°C	-	"	-	
SSEP1S	S/C Separation Status	B,O	BCMRO,OCMRO	8(0)	BL	SEP	NSEP	-	-	-	-	-	
		B,O	BACS,OACS	31(0)	BL	SEP	NSEP	-	-	-	-	-	
		B,O	BENG,OENG,OLACB	15(0)	BL	SEP	NSEP	-	-	-	-	-	
		O	OSUBA	15(0)	BL	SEP	NSEP	-	-	-	-	-	
SSEP2S	S/C Separation Status	B,O	BCMRO,OCMRO	36(0)	BL	SEP	NSEP	-	-	-	-	-	
		B,O	BACS,OACS	63(0)	BL	SEP	NSEP	-	-	-	-	-	
		B,O	BENG,OENG	47(0)	BL	SEP	NSEP	-	-	-	-	-	
		O	OLACB	47(0)	BL	SEP	NSEP	-	-	-	-	-	
		B,O	BSUBA,OSUBA	18(0)	BL	SEP	NSEP	-	-	-	-	-	
VALV1S	Latch Valve 1 Position Status	B,O	BSUBA,OSUBA	7(4)	BL	OPEN	CLOS	-	-	-	-	-	
VALV2S	Latch Valve 2 Position Status	B,O	BSUBA,OSUBA	7(5)	BL	OPEN	CLOS	-	-	-	-	-	
VCASET	OIR Case Temp	O	OSUBA	75	AC	-	-	-				-	

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APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS			E.V. CONVERSION		RANGE	SAMPLE TIME	REMARKS/REF
						BIT =	"O" BIT	MULT.	UNIT	QUANTIZ.			
VFDVHS	Fill and Drain Valve Prt. Heater Status	8	05UR0	50	AN	-	-	-	AMPS	-	0.0 to 0.14	-	
		8	05UR0	62	AN	-	-	-	AMPS	-	0.0 to 0.14	-	
VJ12HS	Radial Jets 1/2 Line Heaters Status	8	05UR0	13	AN	-	-	-	AMPS	-	0.0 to 0.30	-	
		8	05UR0	30	AN	-	-	-	AMPS	-	0.0 to 0.30	-	
VJ34HS	Radial Jets 3/4 Line Heaters Status	8	05UR0	45	AN	-	-	-	AMPS	-	0.0 to 0.22	-	
		0	05UR0	35	AN	-	-	-	AMPS	-	0.0 to 0.22	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS '0' BIT	STATUS '1' BIT	STATUS MULT	E.V. CONVERSION UNIT	E.V. CONVERSION QUANTIZ	RANGE	SAMPLE TIME	REMARKS/REF
VJET1T	Radial Jet 1 Temp	8,0	DACS,OACS,	32	AC	-	-		°C		-100.0 to +100.0	-	
		8,0	OSUBA,OSUBA	38	AC	-	-	-	°C		"	-	
		8	OSUBC	24	AC	-			°C	-	"	-	
VJET2T	Radial Jet 2 Temp	80	DACS,OACS	33	AC	-	-	-	°C		"	-	
		8,0	OSUBA,OSUBA	45	AC	-	-	-	°C	-	"	-	
		8	OSUBC	25	AC	-	-		°C	-	"	-	
VJET3T	Radial Jet 3 Temp	8,0	DACS,OACS	34	AC	-	-	-	°C	-	-100.0 to +100.0	-	
		8,0	OSUBA,OSUBA	46	AC	-	-	-	°C	-	"	-	
		8	OSUBC	26	AC	-	-	-	°C	-	"	-	
VJET4T	Radial Jet 4 Temp	8,0	DACS,OACS	35	AC	-	-	-	°C	-	"	-	
		8	OSUBC	32	AC	-	-	-	°C	-	"		
VJET5T	Forward Axial Jet 5 Temp	8,0	DACS,OACS	36	AC	-	-	-	°C	-	-100.0 to +100.0	-	
		8,0	OSUBA,OSUBA	31	AC	-	-	-	°C	-	"	-	
		8	OSUBC	33	AC	-	-	-	°C	-	"	-	
VJET6T	Forward Axial Jet 6 Temp	8,0	DACS,OACS	37	AC	-	-	-	°C	-	"	-	
		8,0	OSUBA,OSUBA	78	AC	-	-	-	°C	-	"	-	
		8	OSUBC	34	AC	-	-	-	°C	-	"	-	
VJET7T	Forward Axial Jet 7 Temp	8	DACS	38	AC	-	-	-	°C	-	-100.0 to +100.0	-	
		0	OE,DB	51	AC	-	-	-	°C	-	"	-	
VLIN1T	Propellant Line 1 Temp	8,0	OSUBA,OSUBA	35	AC	-	-	-	°C	-	-10.0 to +50.0	-	
VLIN2T	" " 2 "	8,0	OSUBA,OSUBA	36	AC	-	-	-	°C	-	"	-	
VLIN3T	" " 3 "	8,0	OSUBA,OSUBA	37	AC	-	-	-	°C	-	"	-	
VLIN4T	" " 4 "	8,0	OSUBA,OSUBA	38	AC	-	-	-	°C	-	"	-	
VLHPRS	Latch Valve Primary Heater Status	8	OSUBA	43	AN	-	-	-	AMPS	-	0.0 to 0.6	-	
		0	OSUBD	57	AN	-	-	-	AMPS	-	0.0 to 0.6	-	
VSAF1T	S&A Safe and Arm Temp	0	OE,DB	26	AC	-	-	-	°C	-		-	
VTANKP	Tank Pressure	8,0	DACS,OACS	11	AC	-	-	-	PSI	-	0.0 to 300	-	
		8,0	OE,DB,OE,DB	63	AC	-	-	-	PSI	-	0.0 to 300	-	
		8,0	OSUBA,OSUBA	21	AC	-	-	-	PSI	-	0.0 to 300	-	
		80	DCTS	56	AC	-	-	-	PSI	-	0.0 to 300	-	

APPENDIX B: TELEMETRY REFERENCE DATA
(MNEMONICS IN ALPHABETICAL ORDER)

MNEMONIC	DESCRIPTION	APPL. S/C	FORMATS	WORD (BIT)	DATA TYPE	STATUS			E.U. CONVERSION		RANGE	SAMPLE TIME	REMARKS/REF
						1BIT*	"0"BIT*	MULT.	UNIT	QUANTIZ.			
VT[illegible]	[illegible] Thrust Temp	[illegible]	[illegible]	[illegible]	AC	*	*	*	°C			*	
VT[illegible]	Tank 1 Temp	[illegible]	[illegible]	[illegible]	AC		*	*	°C	*	[illegible]	*	
VT[illegible]	Tank 2 Temp	[illegible]	[illegible]	[illegible]	AC	*	*	*	°C	*	[illegible]	*	

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APPENDIX C

FOLD-OUT DIAGRAMS

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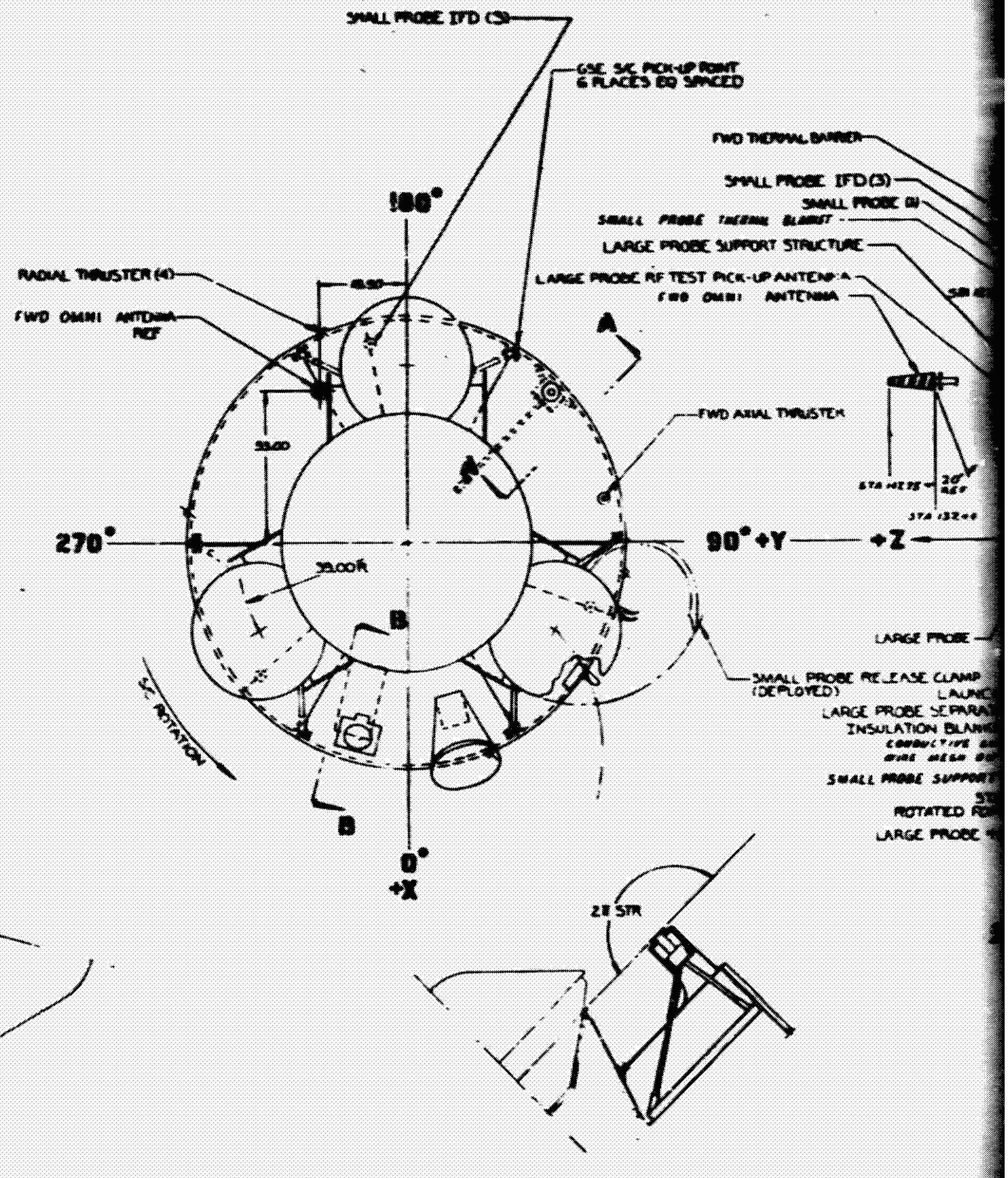
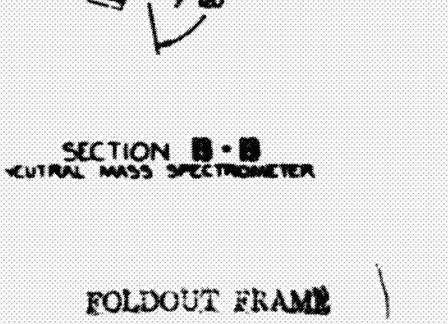
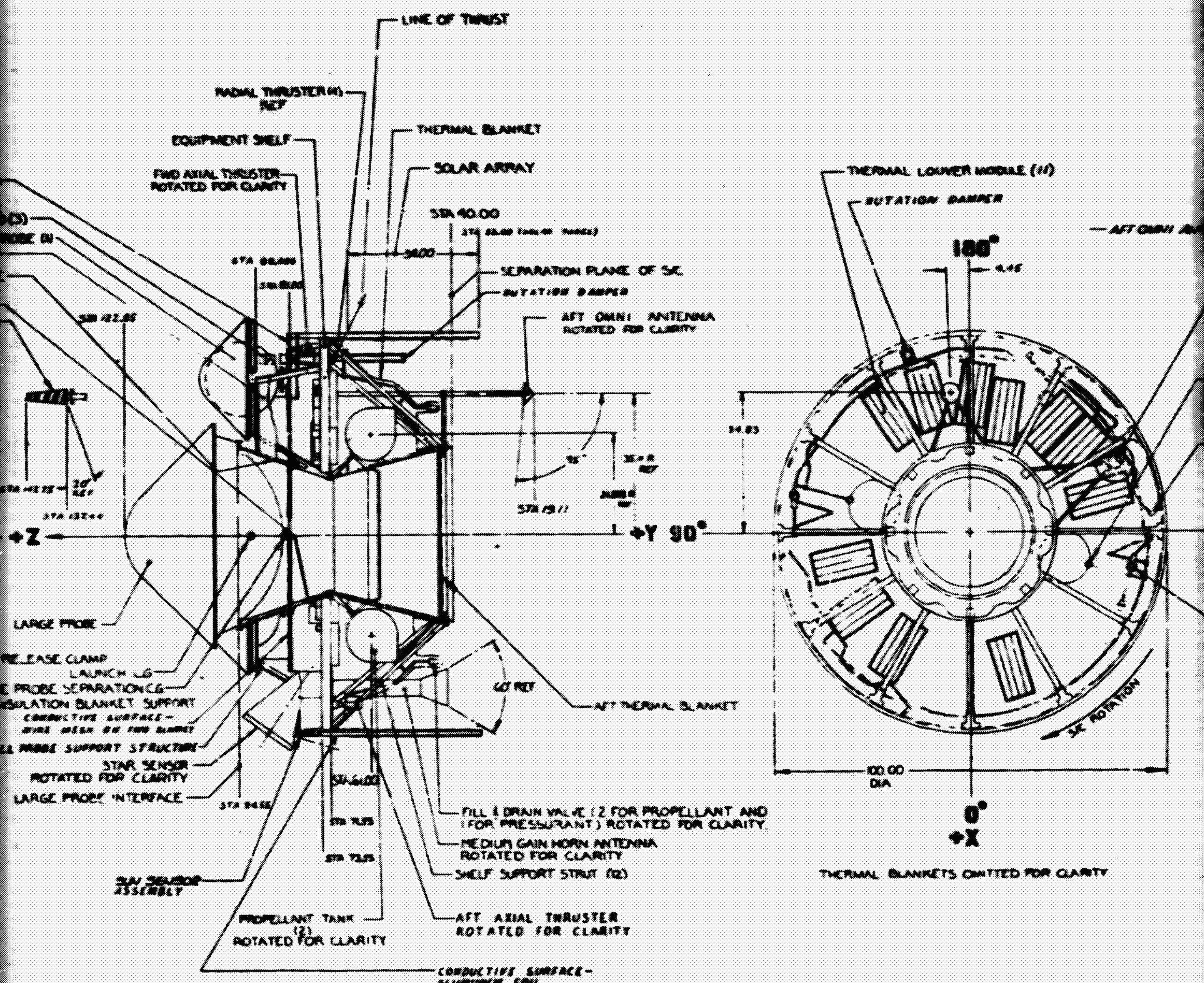




SECTION B - B
NEUTRAL MASS SPECTROMETER

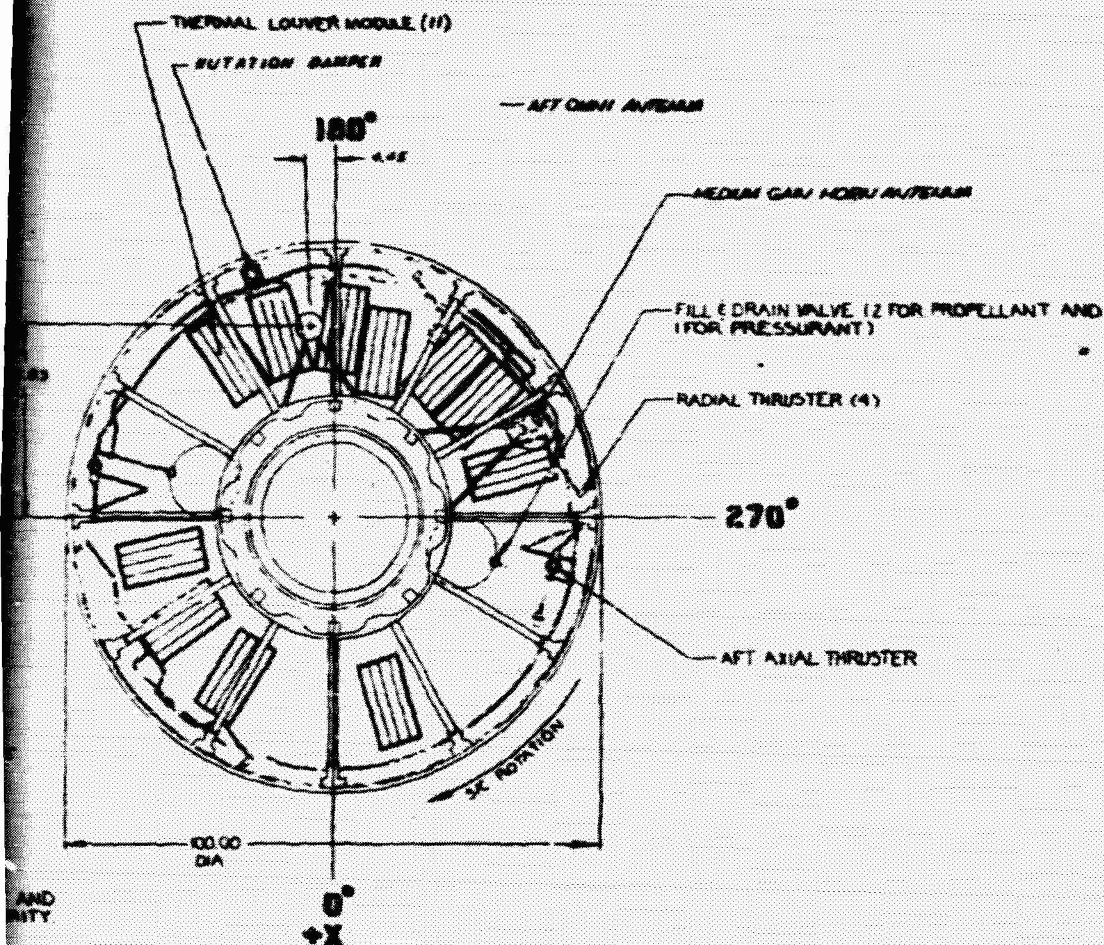
SECTION A - A
ION MASS SPECTROMETER

FOLDOUT FRAME



FOLDOUT FRAME 2

FIGURE 3.1.1.1-1. MU



THERMAL BLANKETS OMITTED FOR CLARITY

FOLDOUT FRAME

FIGURE 3.1.1.1-1. MULTIPROBE GENERAL ARRANGEMENT

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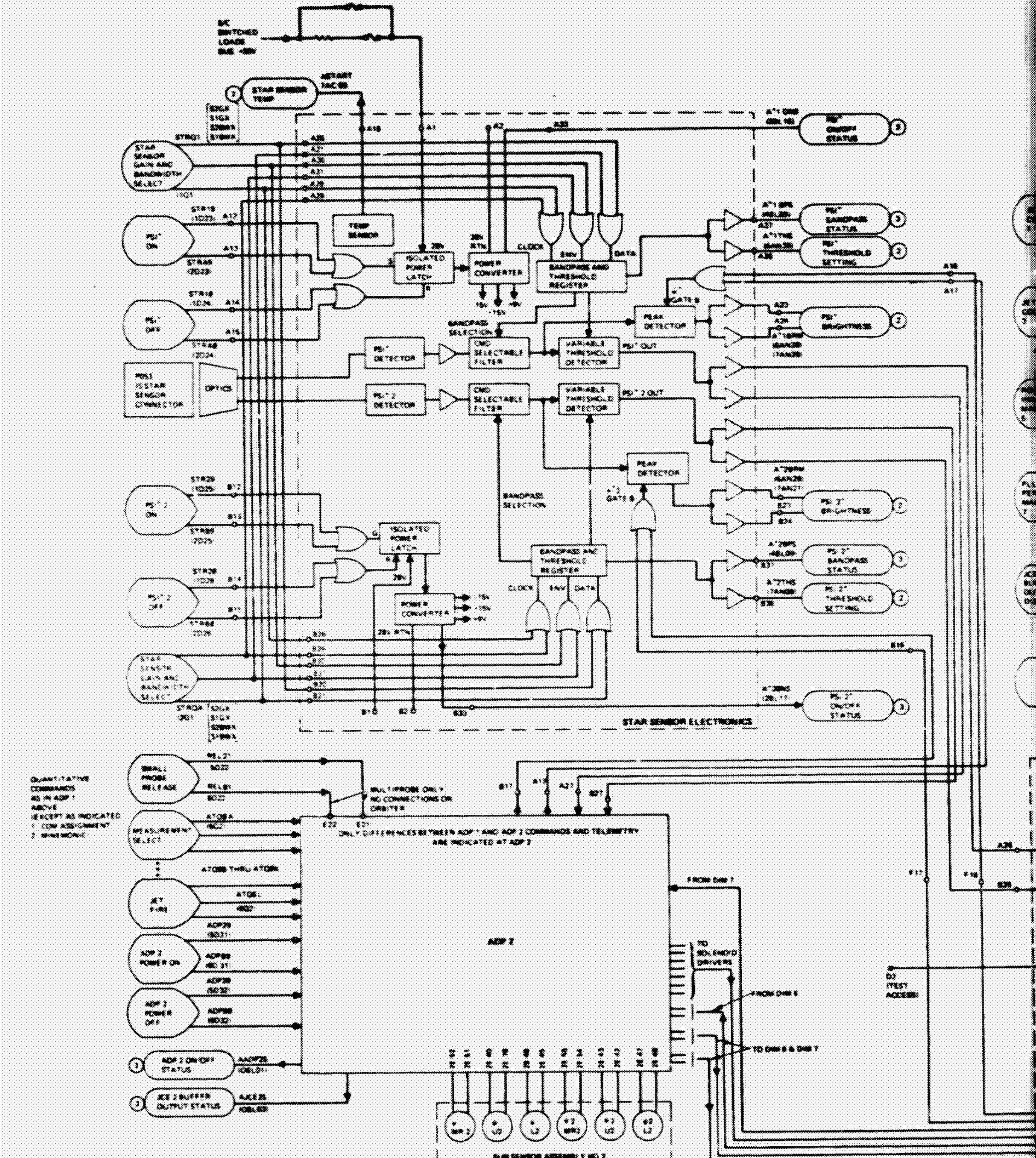

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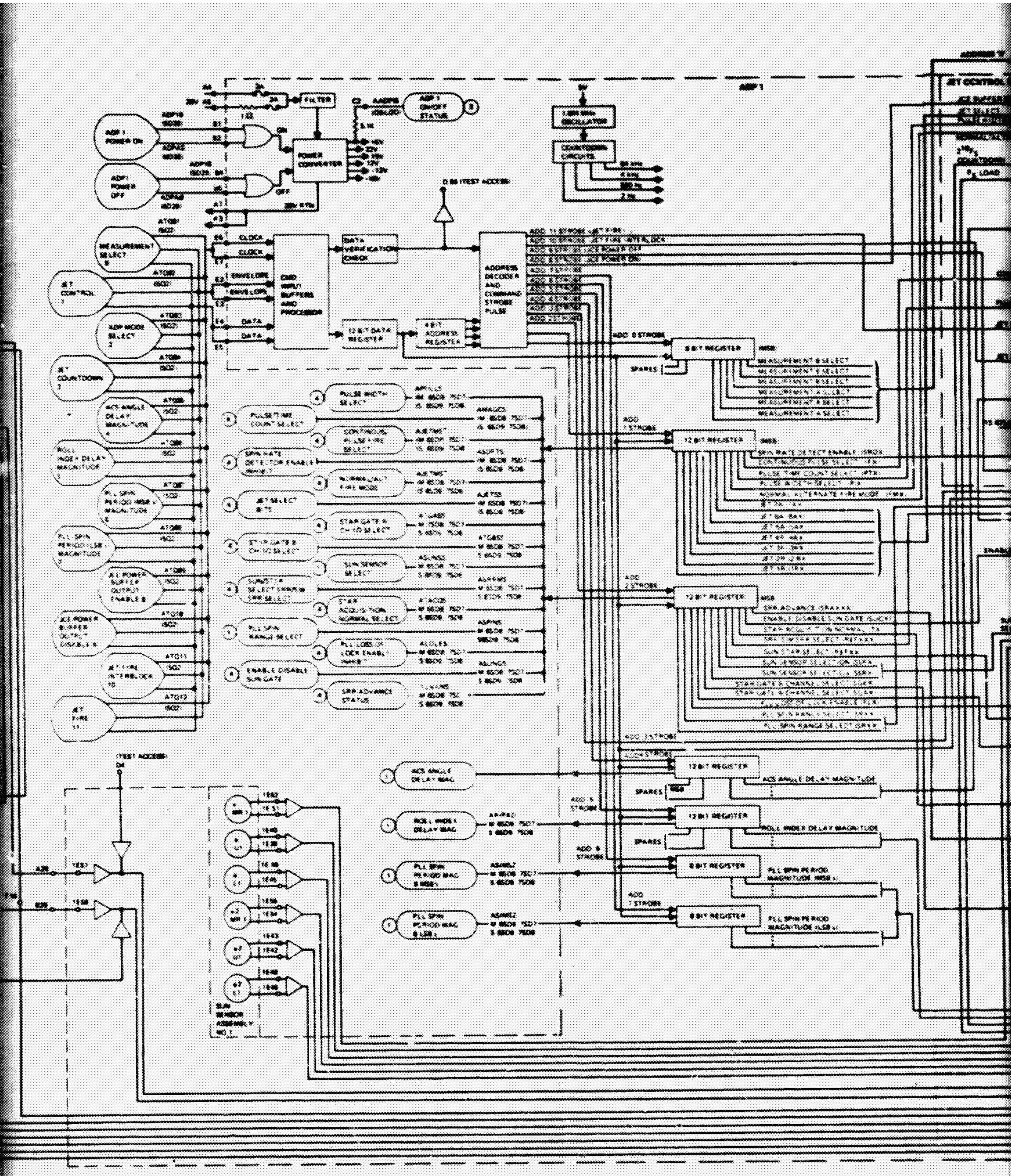

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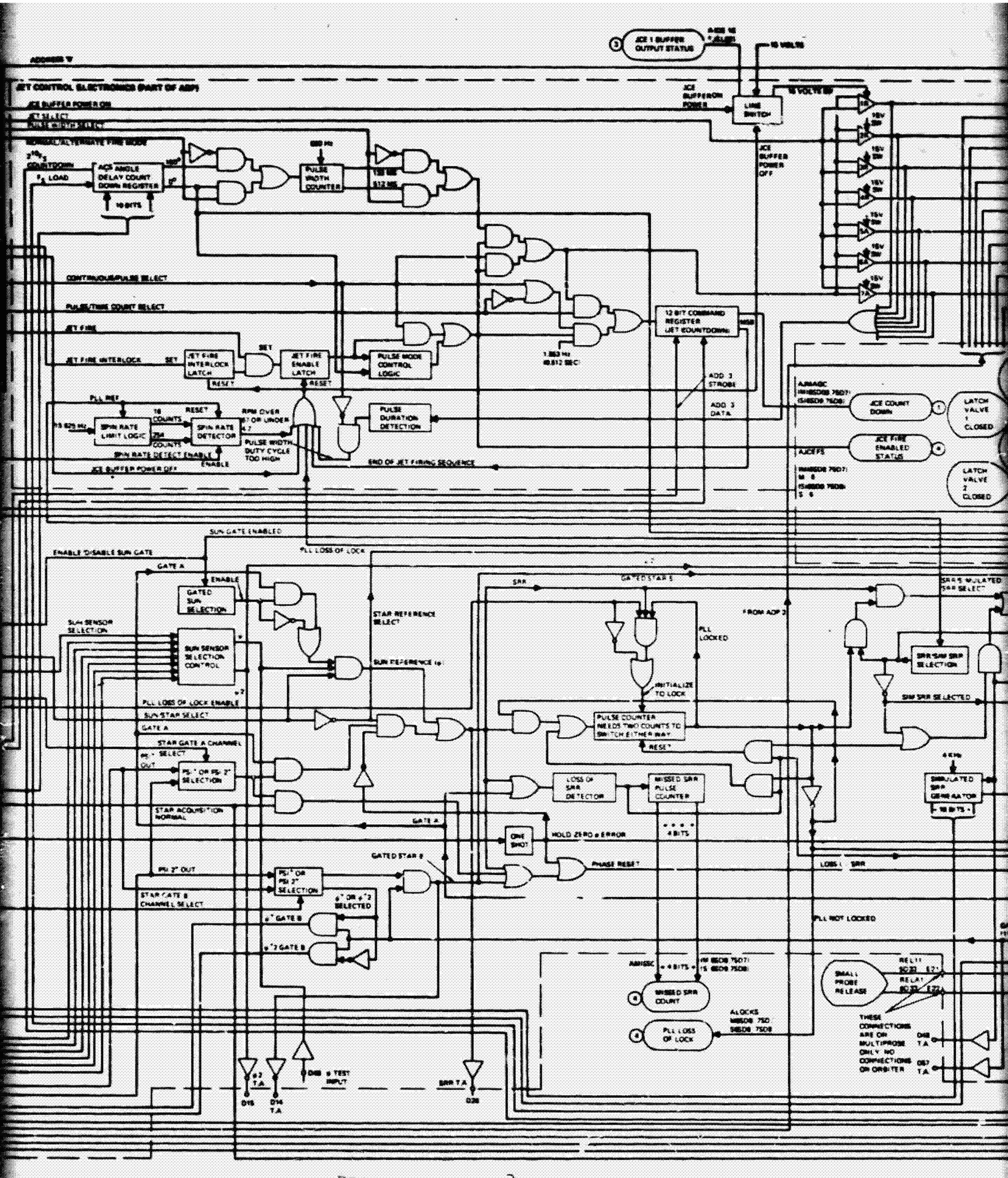

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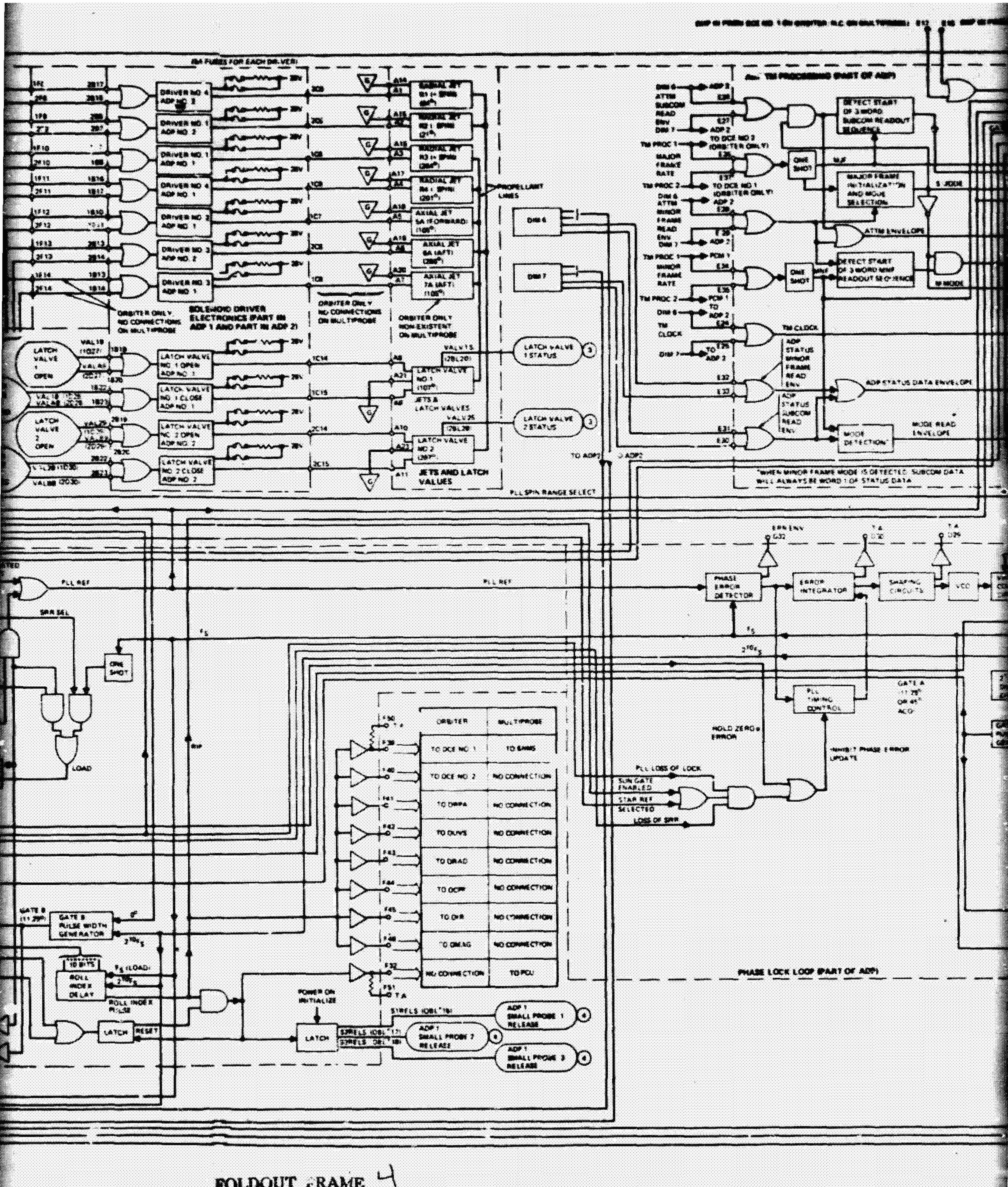

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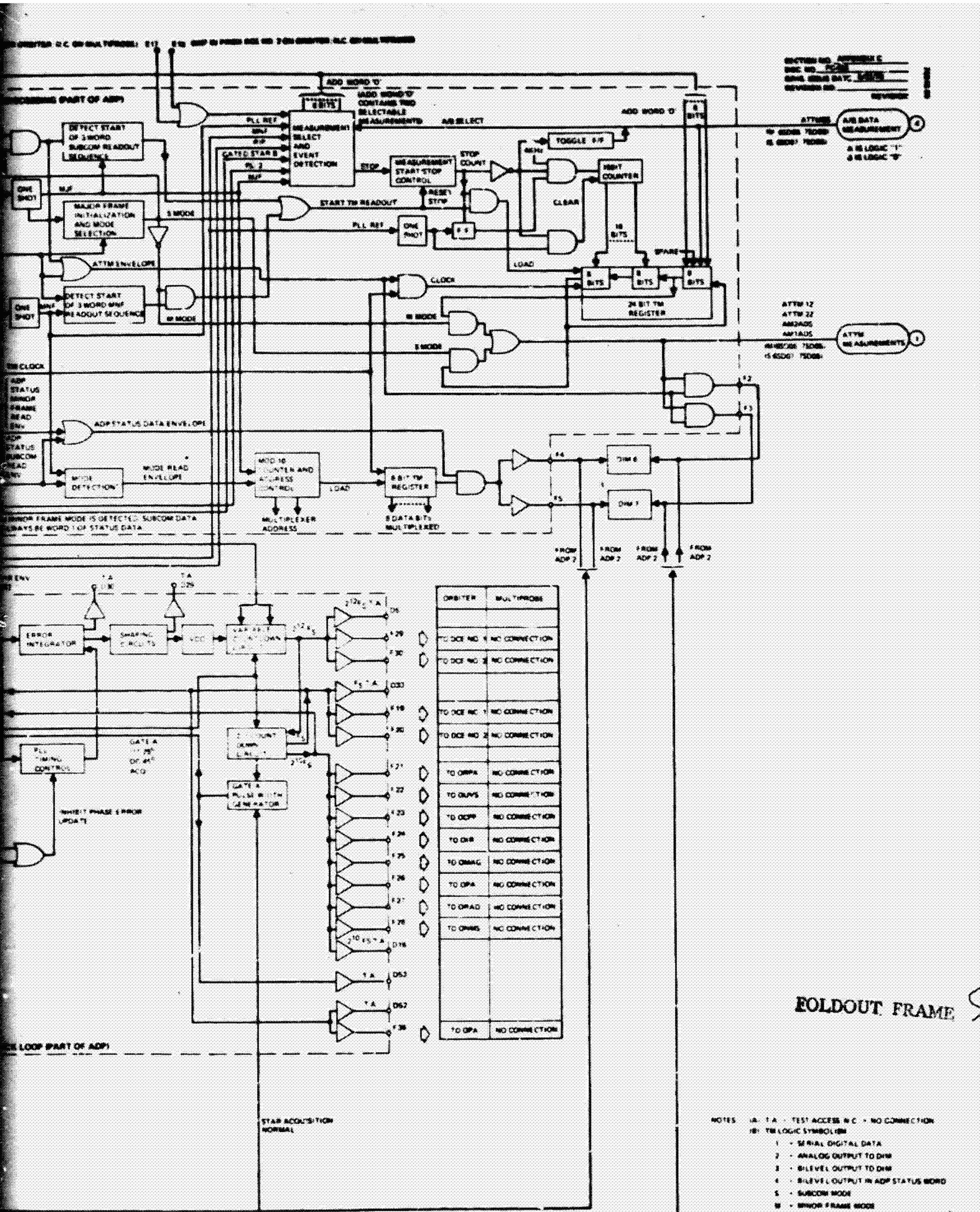
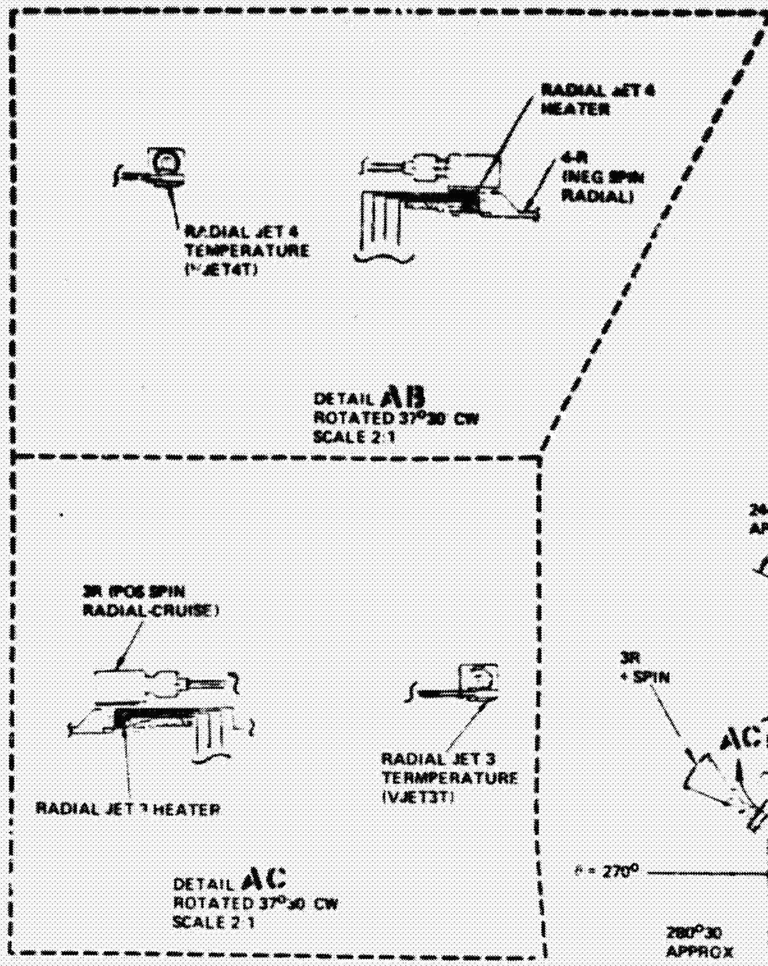


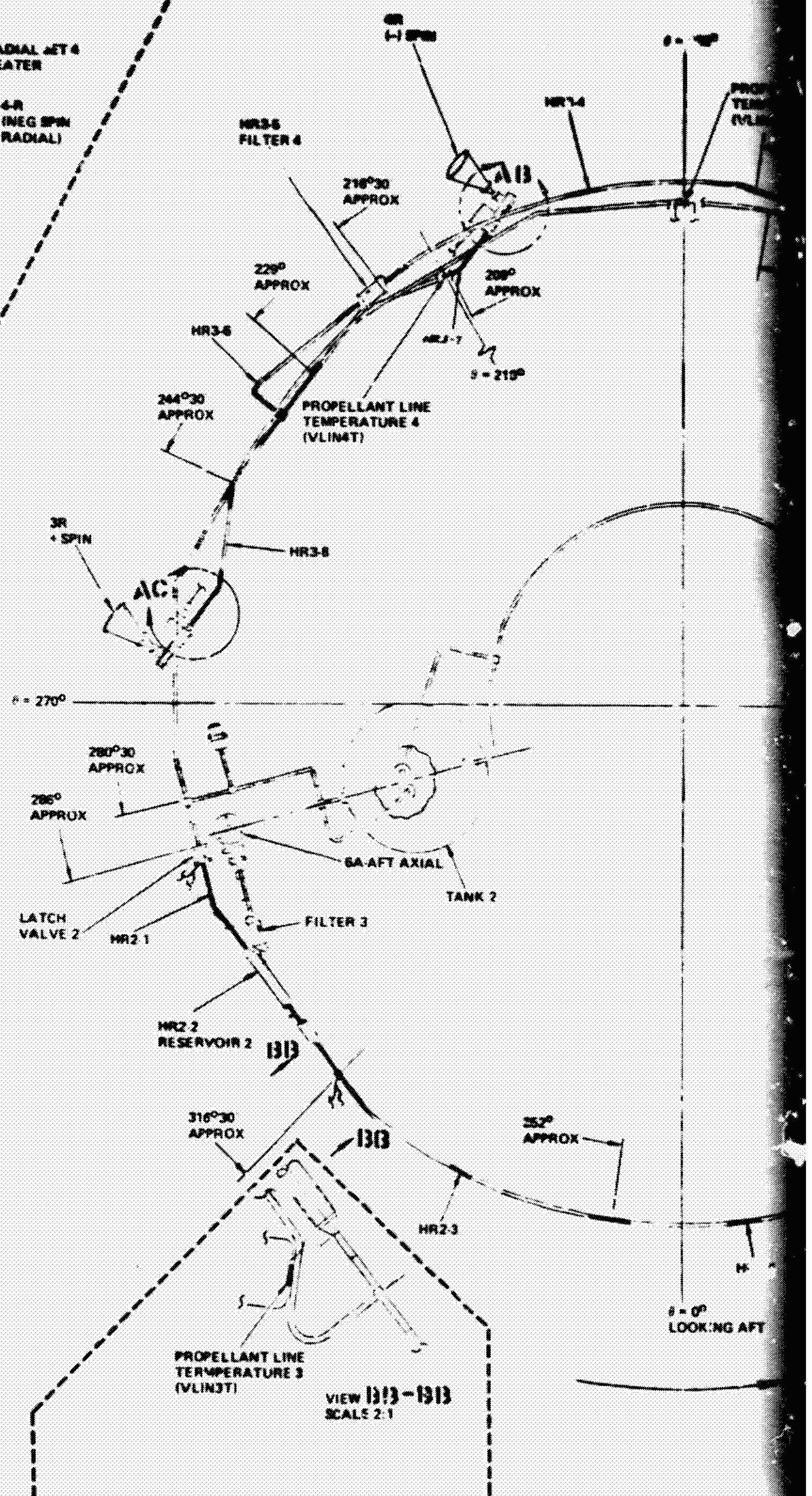
FOLDOUT FRAME 5

NOTES: (A) T.A. = TEST ACCESS N.C. = NO CONNECTION
(B) TM LOGIC SYMBOLISM
1 = SERIAL DIGITAL DATA
2 = ANALOG OUTPUT TO DIM
3 = BILEVEL OUTPUT TO DIM
4 = BILEVEL OUTPUT IN ADP STATUS WORD
5 = SUBCOM MODE
M = MINOR FRAME MODE

SHEET NO C4/C4

FIGURE 3.3.2.3-1 SUN SENSORS, STAR SENSOR ELECTRONICS, ADP, JETS AND LATCH VALVES COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM





NOTE:

1) EACH OF THE FOLLOWING HEATERS IS POWERED ON CONTINOUSLY FROM THE 28 VOLTS ESSENTIAL BUS, AND IS NOT CONNECTED IN SERIES WITH ANY OTHER HEATERS (SEE FIGURE 3.8.1-1 FOR SCHEMATIC)

A) RADIAL JET 1 HEATER

B) RADIAL JET 2 HEATER

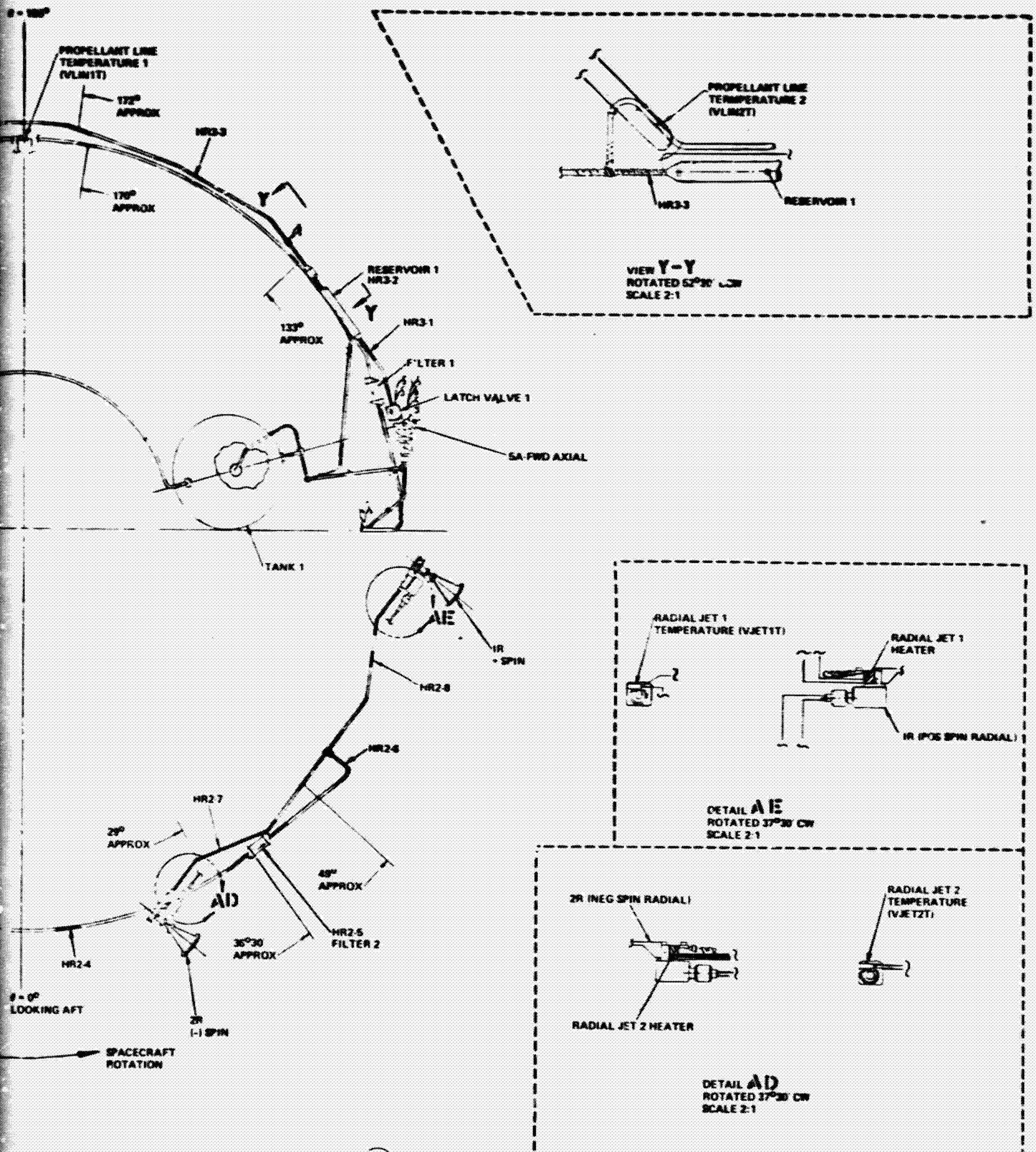
C) RADIAL JETS 1 AND 2 LINE HEATERS

D) RADIAL JET 3 HEATER

E) RADIAL JET 4 HEATER

F) RADIAL JETS 3 AND 4 LINE HEATERS

FOLDOUT FRAME 1



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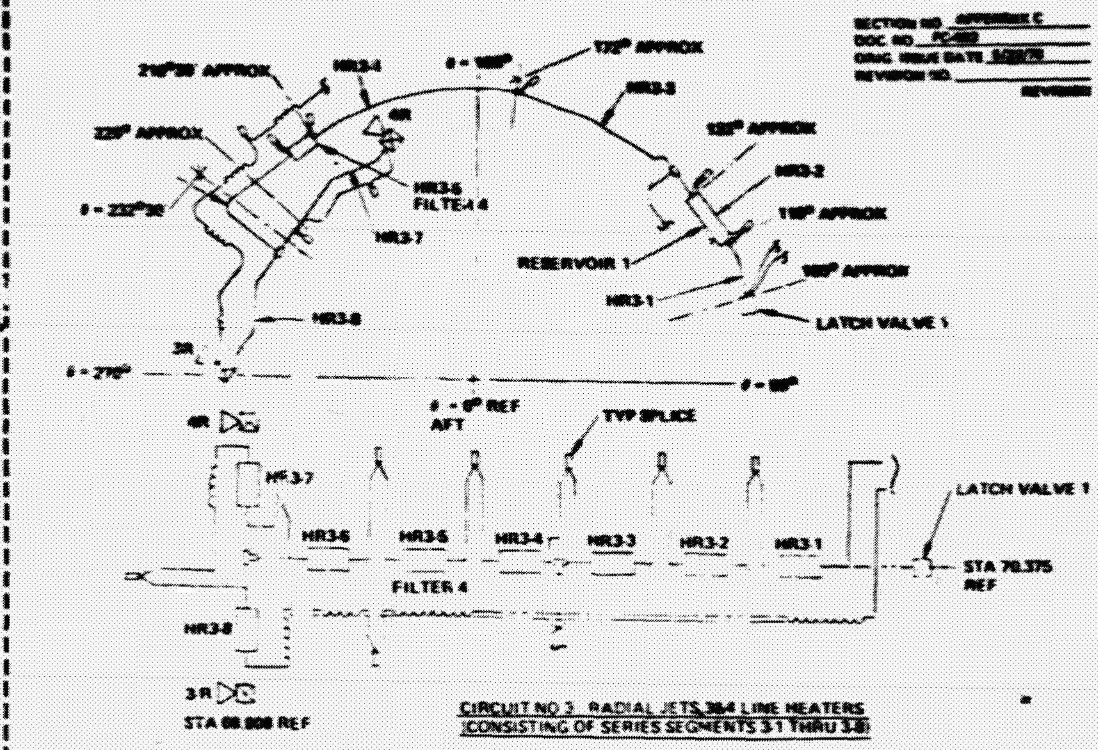


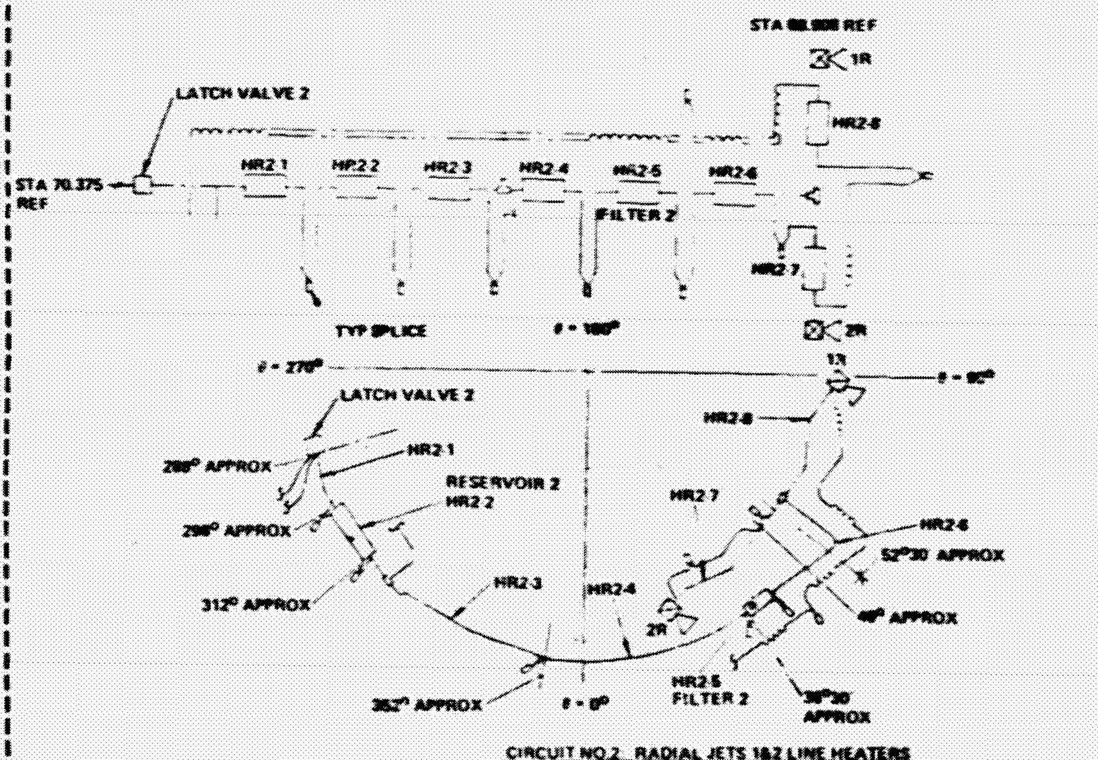
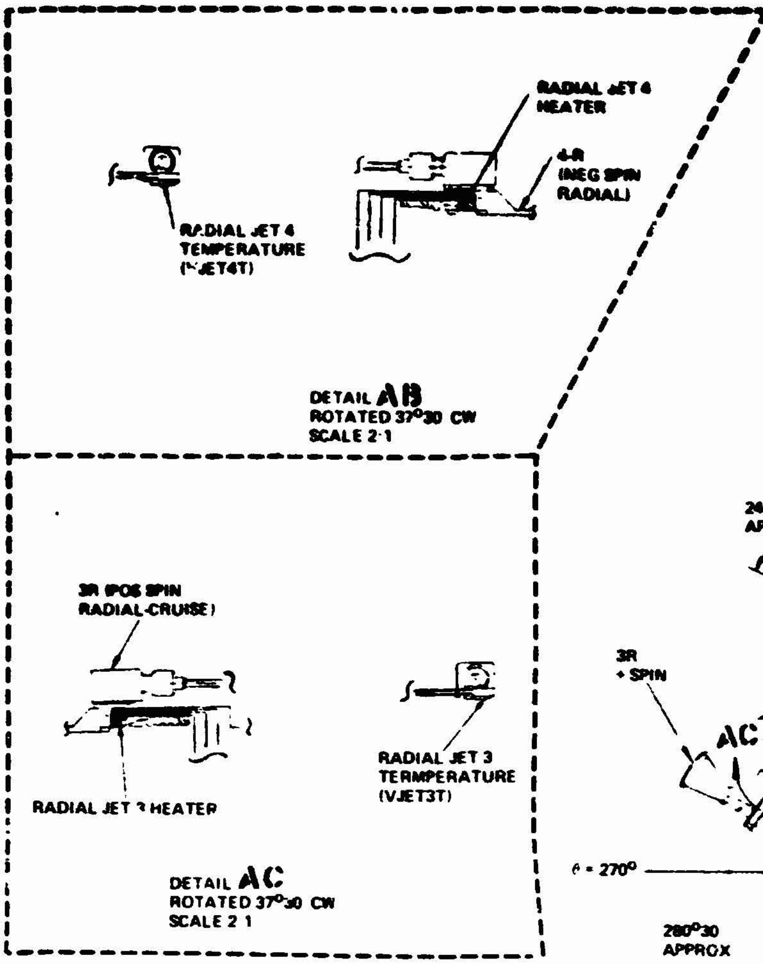
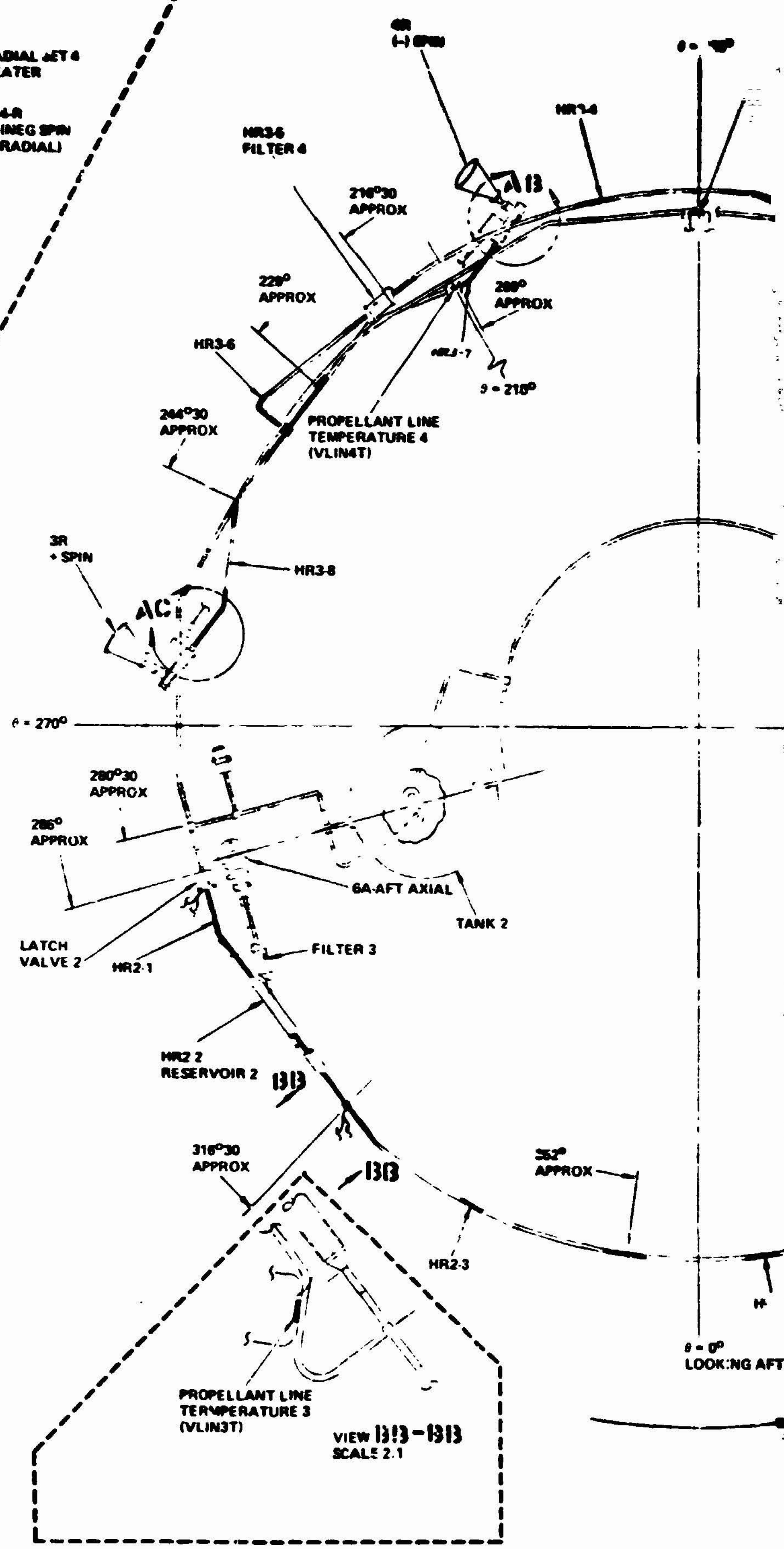


FIGURE 3.2.1.1. PROPULSION HEATERS AND TEMPERATURE SENSORS
PART 1 OF 3 PARTS. HEATERS THAT ARE POWERED ON CONTINOUSLY
AND ASSOCIATED TELEMETERED TEMPERATURE SENSORS

SHEET NO. C-7/C-8

FOLDOUT FRAME 2





NOTE

1) EACH OF THE FOLLOWING HEATERS IS POWERED ON CONTINOUSLY FROM THE 28 VOLTS ESSENTIAL BUS AND IS NOT CONNECTED IN SERIES WITH ANY OTHER HEATERS (SEE FIGURE 3.8.1.1 FOR SCHEMATIC)

- A) RADIAL JET 1 HEATER
- B) RADIAL JET 2 HEATER
- C) RADIAL JETS 1 AND 2 LINE HEATERS
- D) RADIAL JET 3 HEATER
- E) RADIAL JET 4 HEATER
- F) RADIAL JETS 3 AND 4 LINE HEATERS

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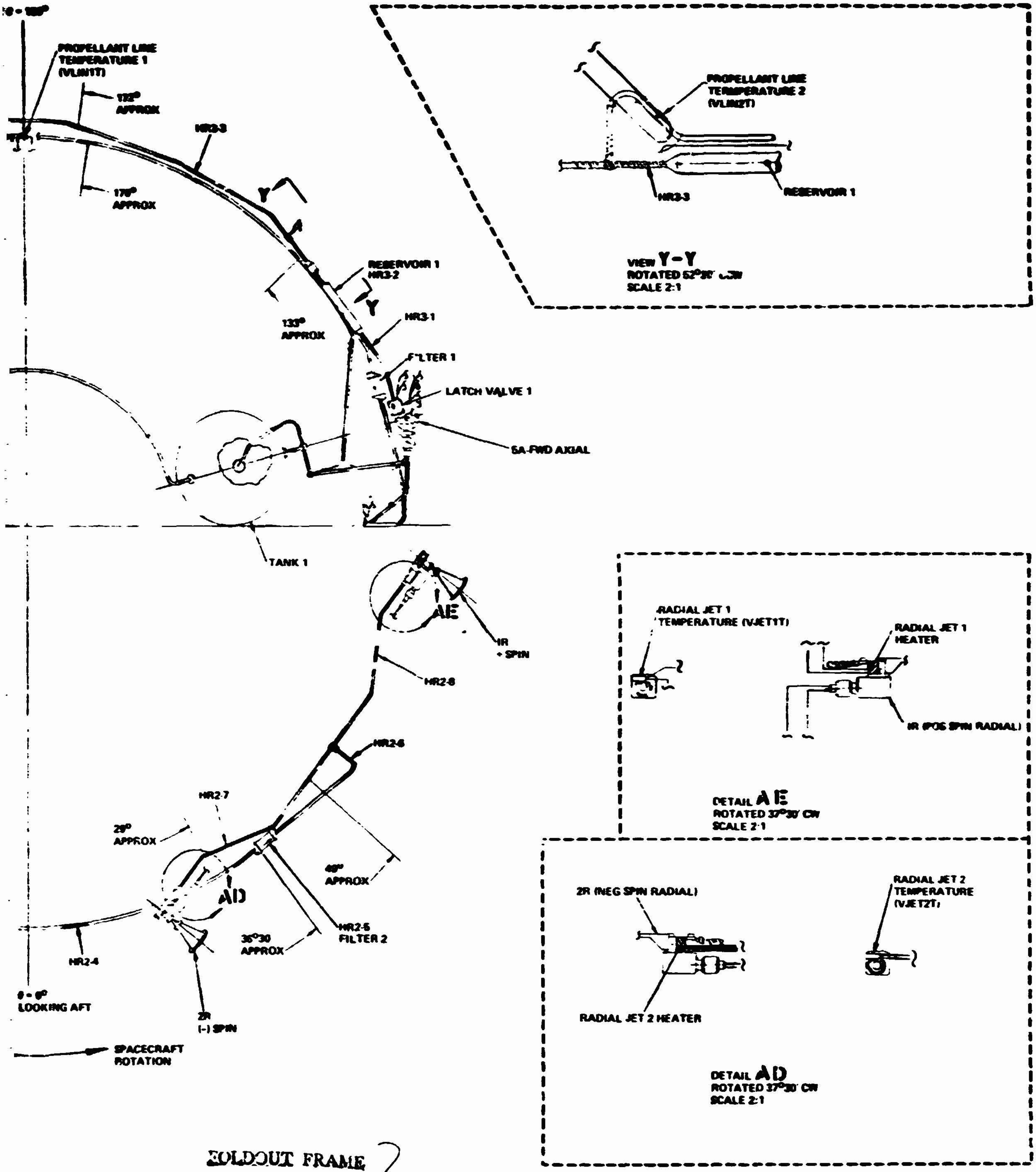

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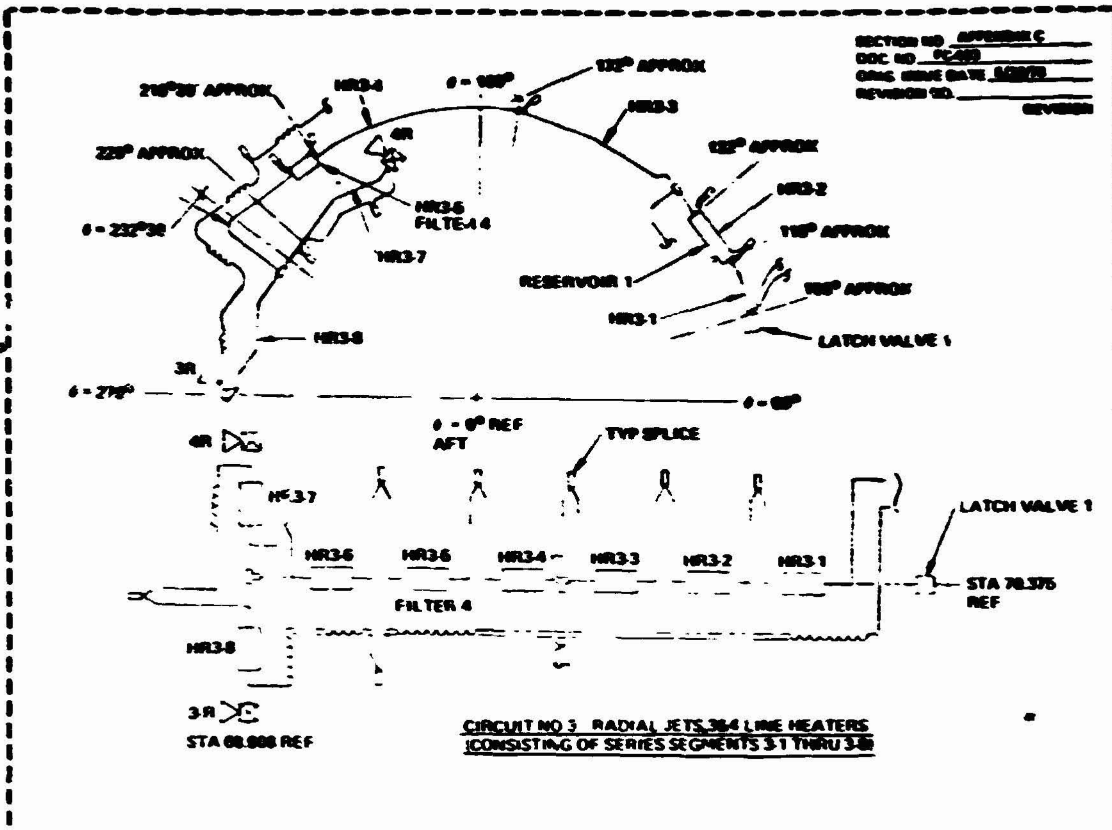

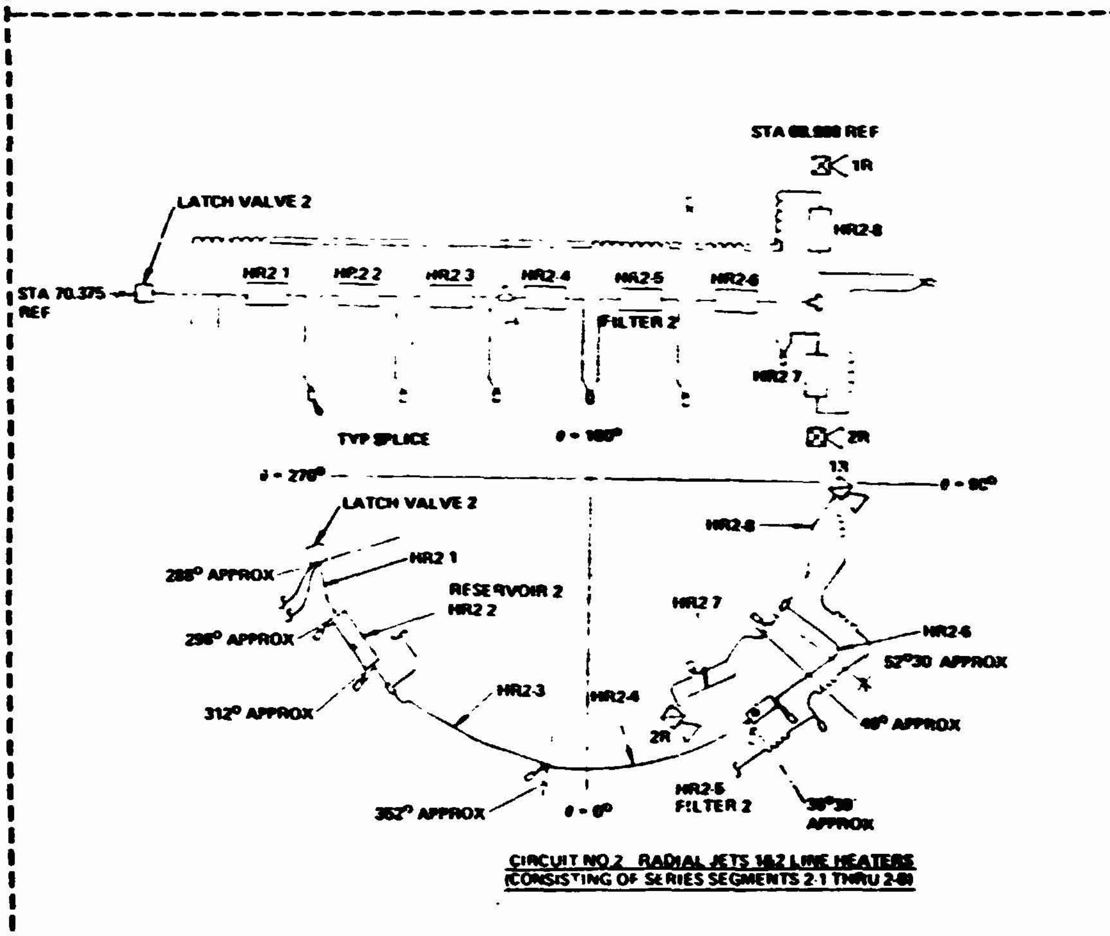

FIGURE 3.2.1.1 PROPULSION HEATERS AND TEMPERATURE SENSORS
PART 1 OF 3 PARTS HEATERS THAT ARE POWERED ON CONTINUOUSLY AND ASSOCIATED TELEMETERED TEMPERATURE SENSORS

SHEET NO C-7/C-8

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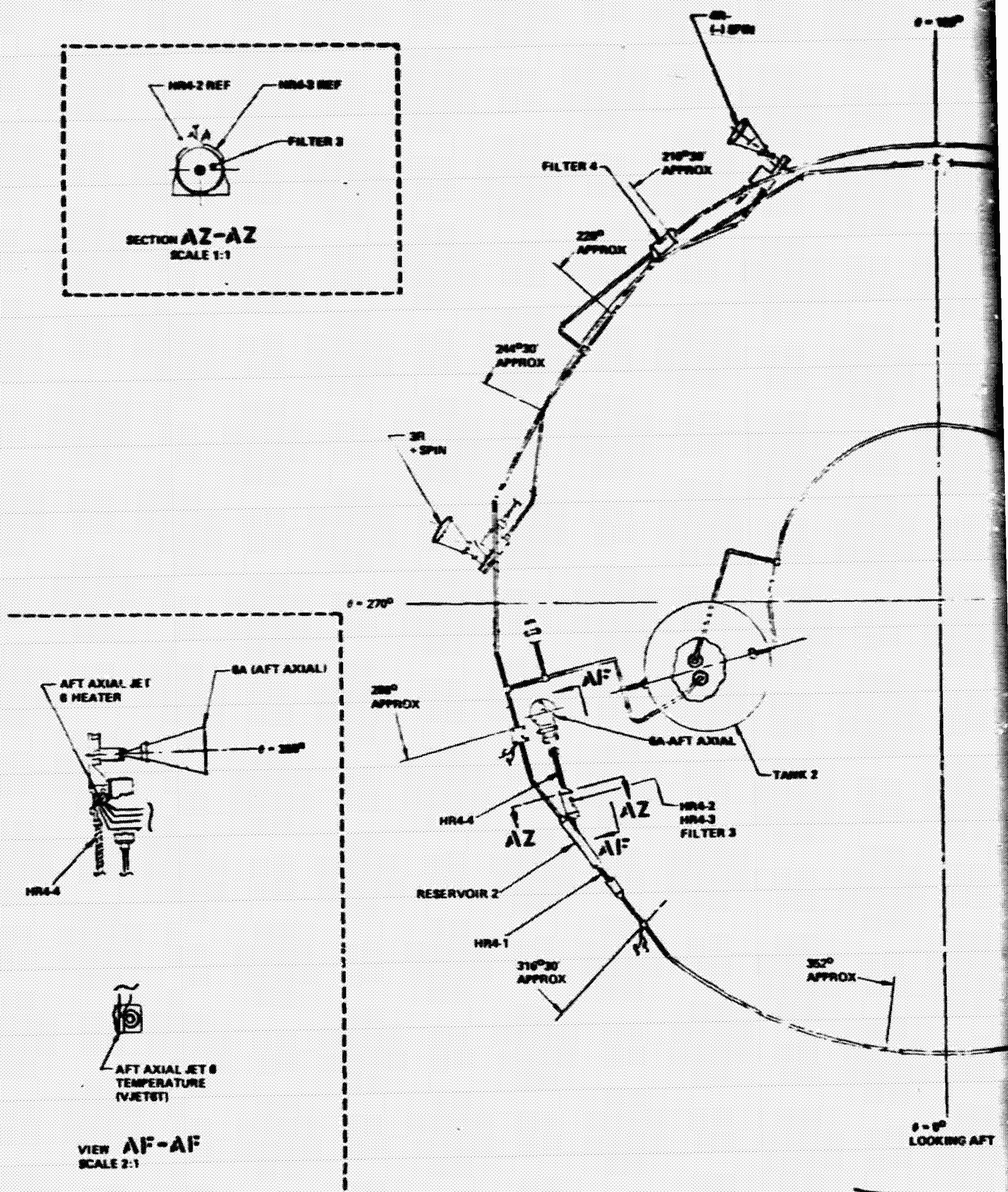

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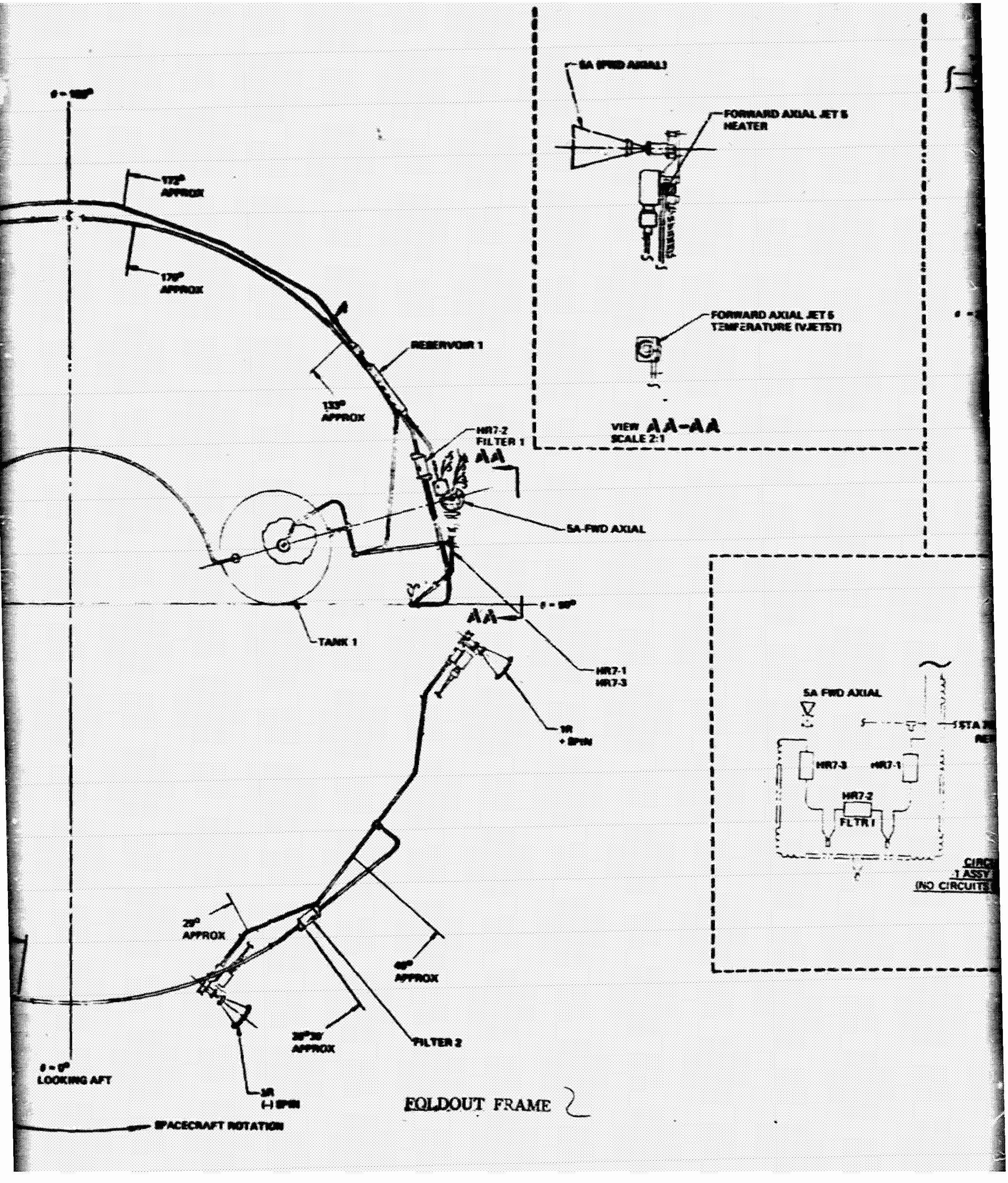

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...ARD AXIAL JET 5
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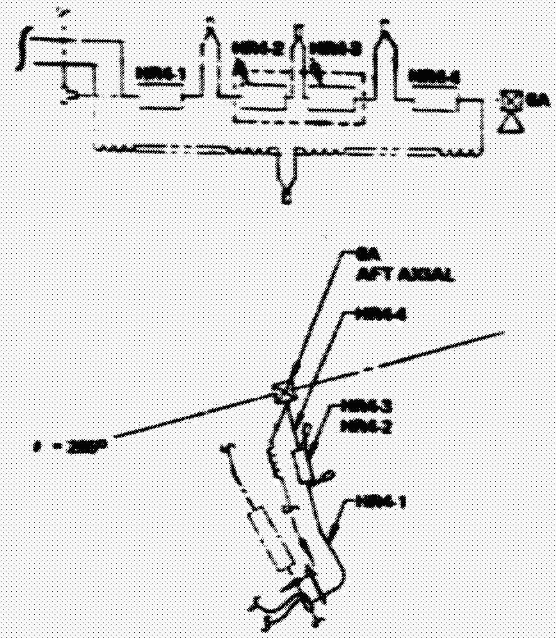
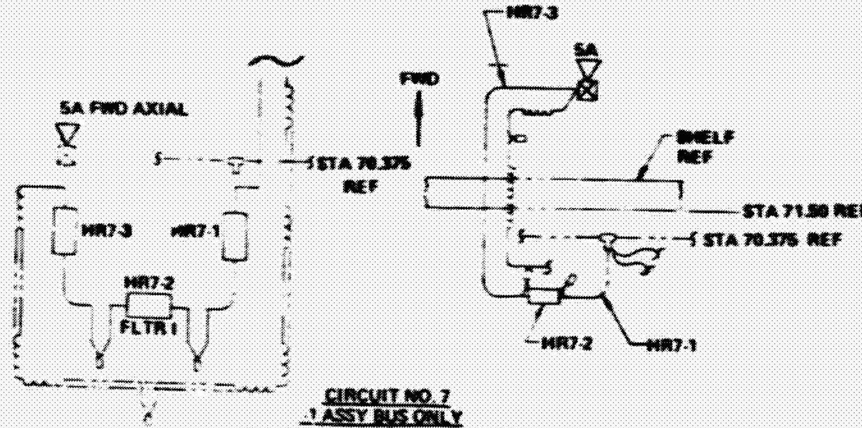


CIRCUIT NO. 4: AFT AXIAL JET 6 LINE HEATERS (CONSISTING OF SERIES SEGMENTS 4-1 THRU 4-4)



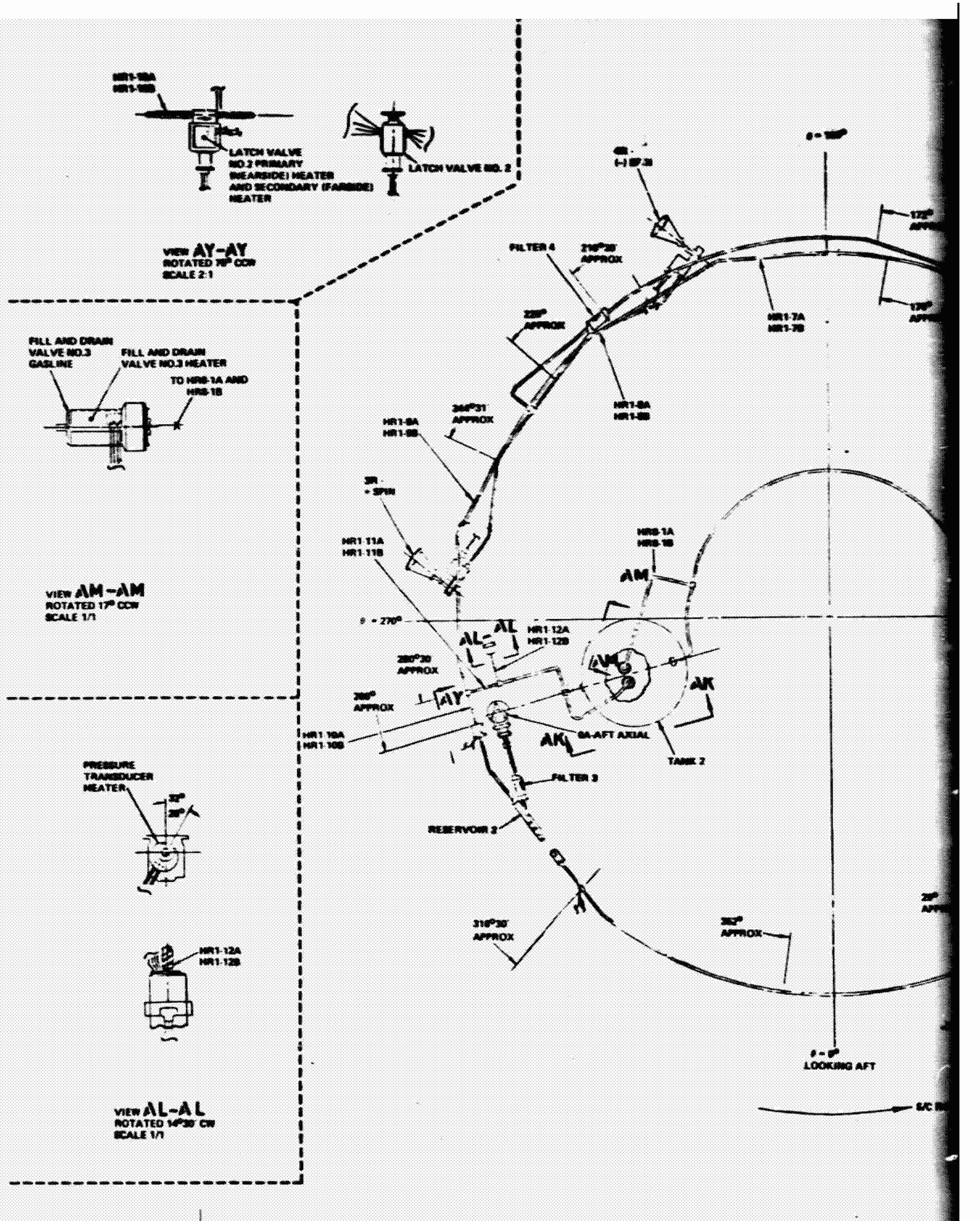
CIRCUIT NO. 7
-1 ASSY BUS ONLY
(NO CIRCUITS 5 AND 6 ON BUS):

AFT AXIAL JET 5 LINE HEATERS (CONSISTING OF SERIES SEGMENTS 7-1 THRU 7-3)

FOLDOUT FRAME 3

FIGURE 3.2.1-1. PROPULSION HEATERS AND TEMPERATURE SENSORS

PART 2 OF 3 PARTS: AXIAL JETS HEATERS, ASSOCIATED LINES HEATERS, AND ASSOCIATED TELEMETERED TEMPERATURE SENSORS.



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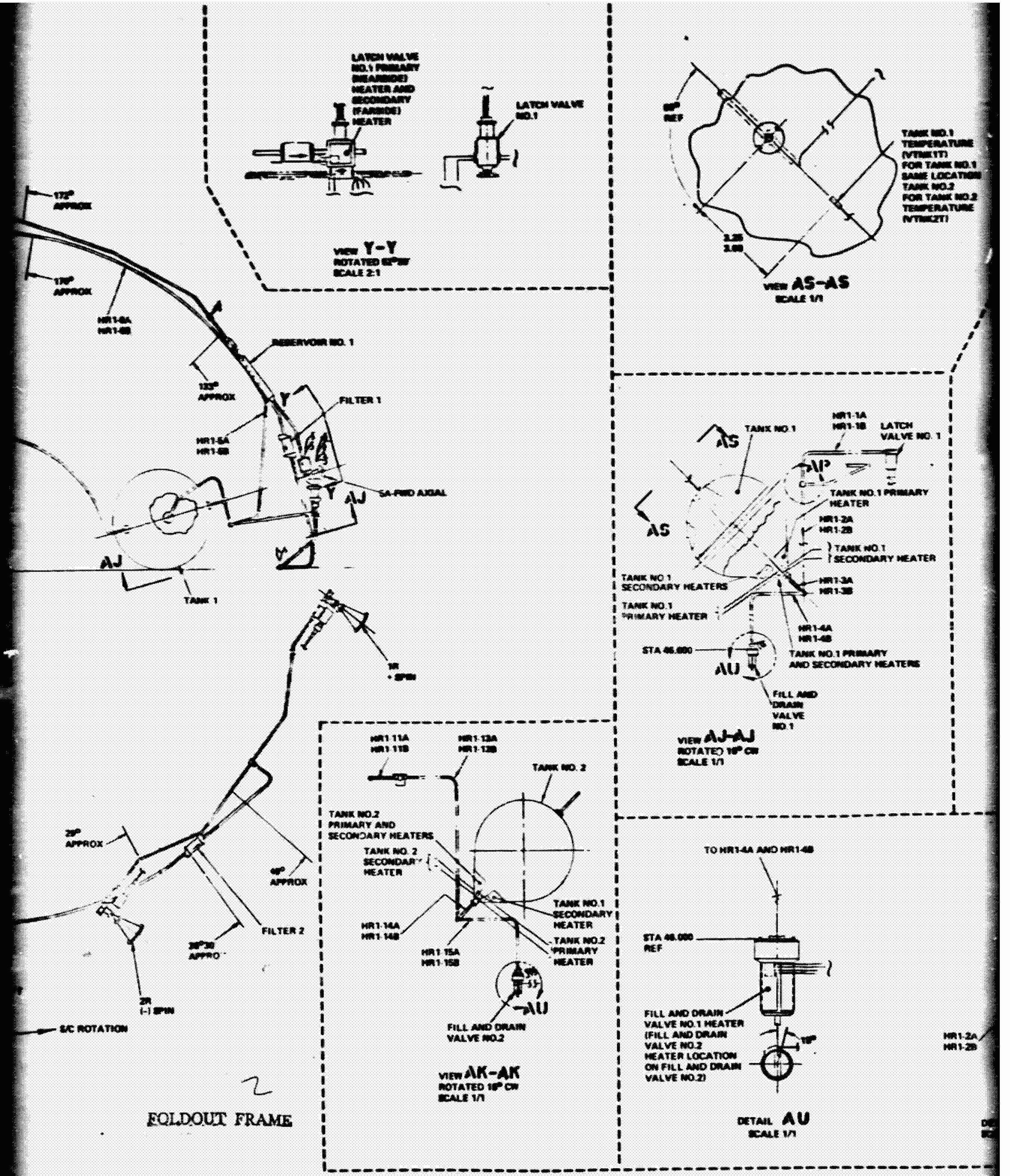

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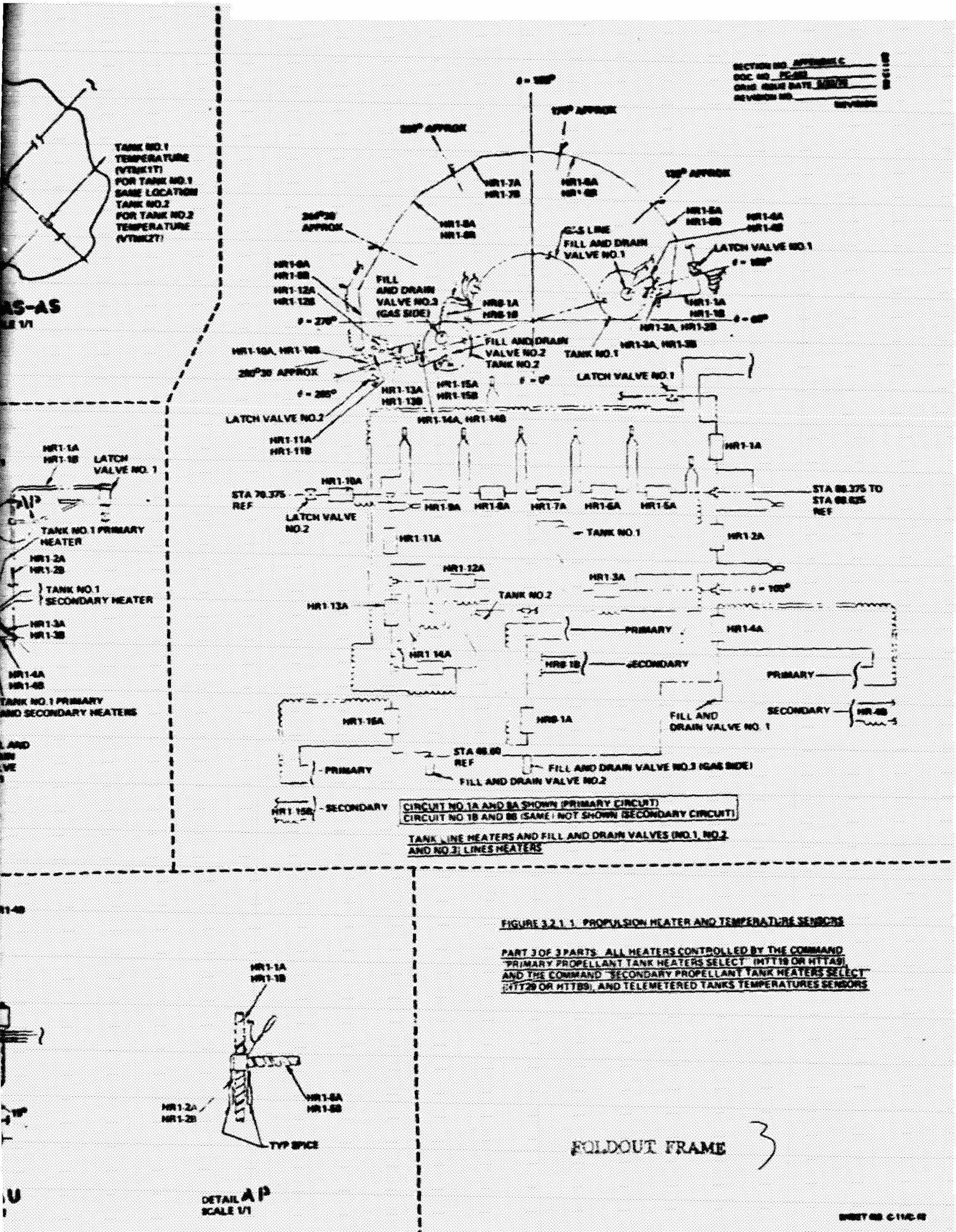
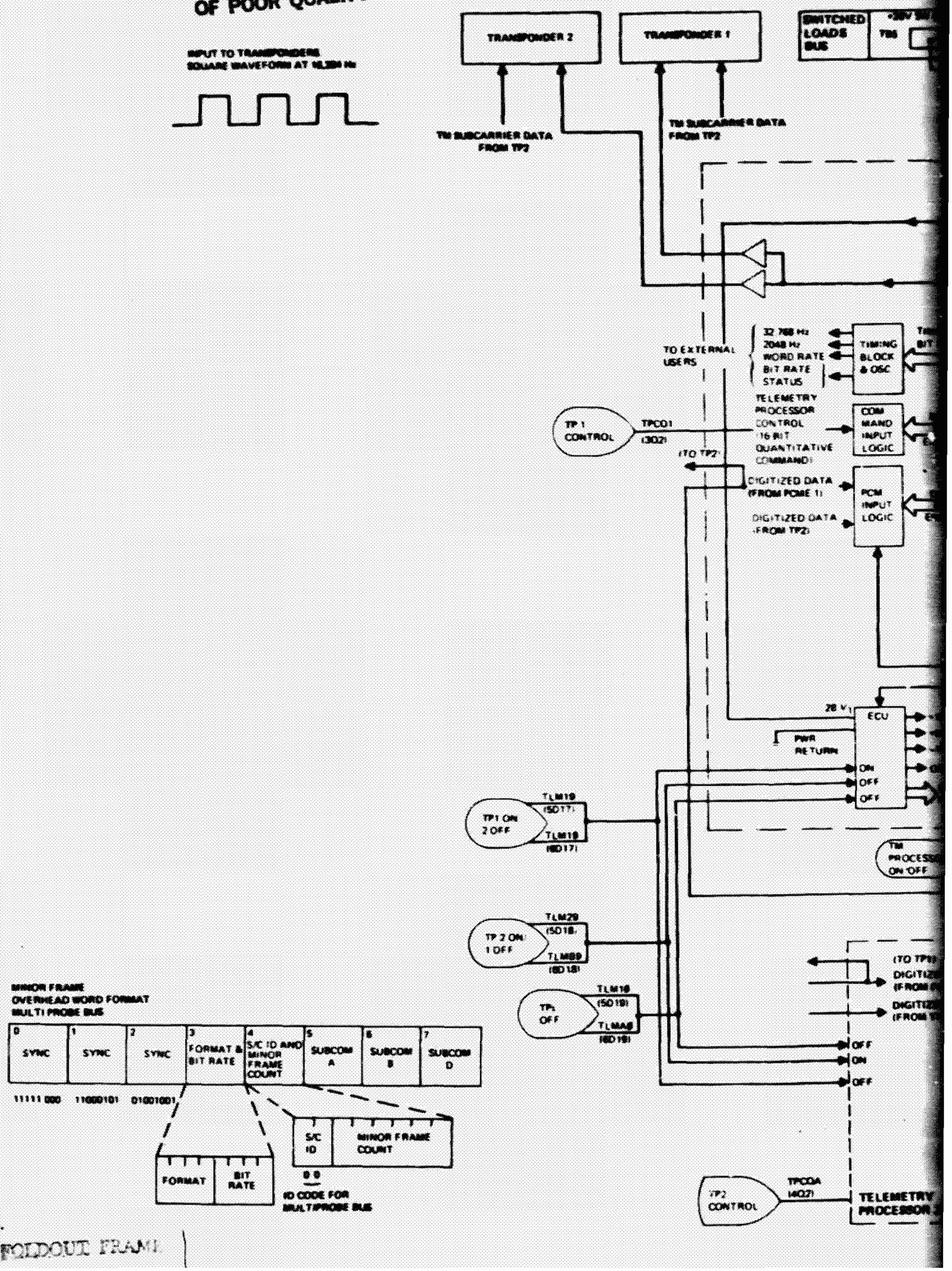


FIGURE 3.2.1.1 PROPULSION HEATER AND TEMPERATURE SENSORS

PART 3 OF 3 PARTS: ALL HEATERS CONTROLLED BY THE COMMAND "PRIMARY PROPELLANT TANK HEATERS SELECT" (HTT19 OR HTTA9), AND THE COMMAND "SECONDARY PROPELLANT TANK HEATERS SELECT" (HTT29 OR HTTB9), AND TELEMETERED TANKS TEMPERATURES SENSORS

FOLDOUT FRAME 3



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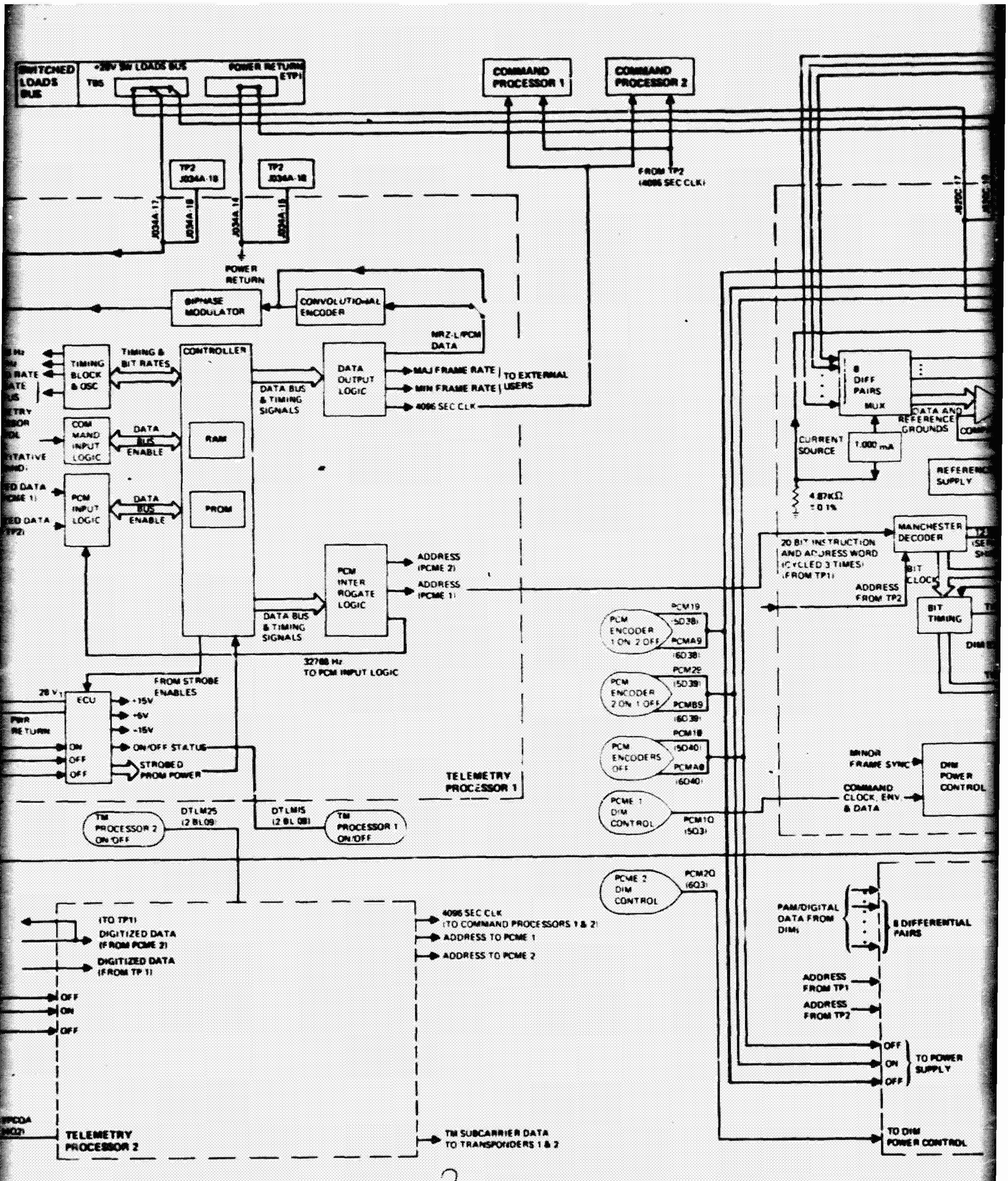

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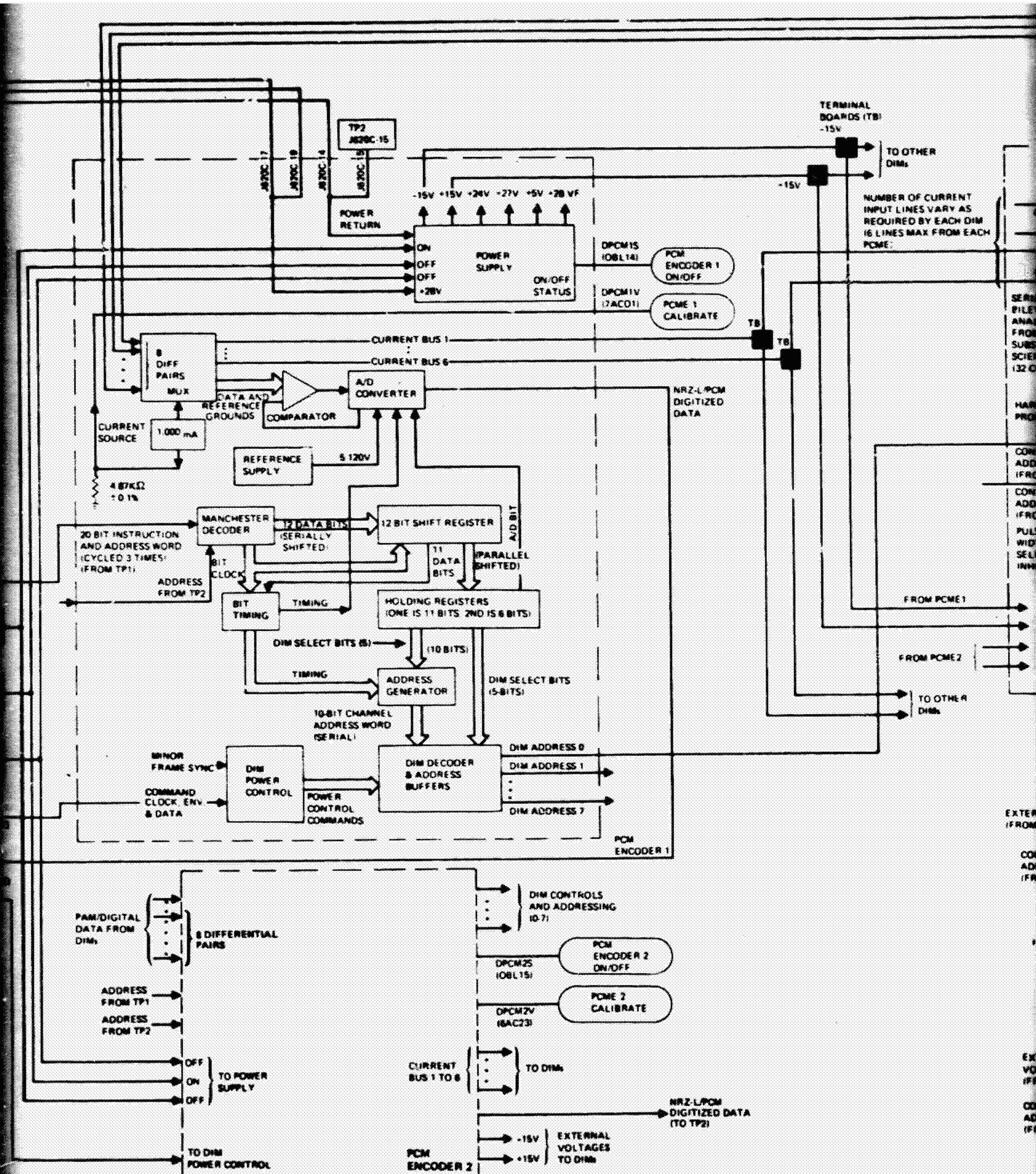

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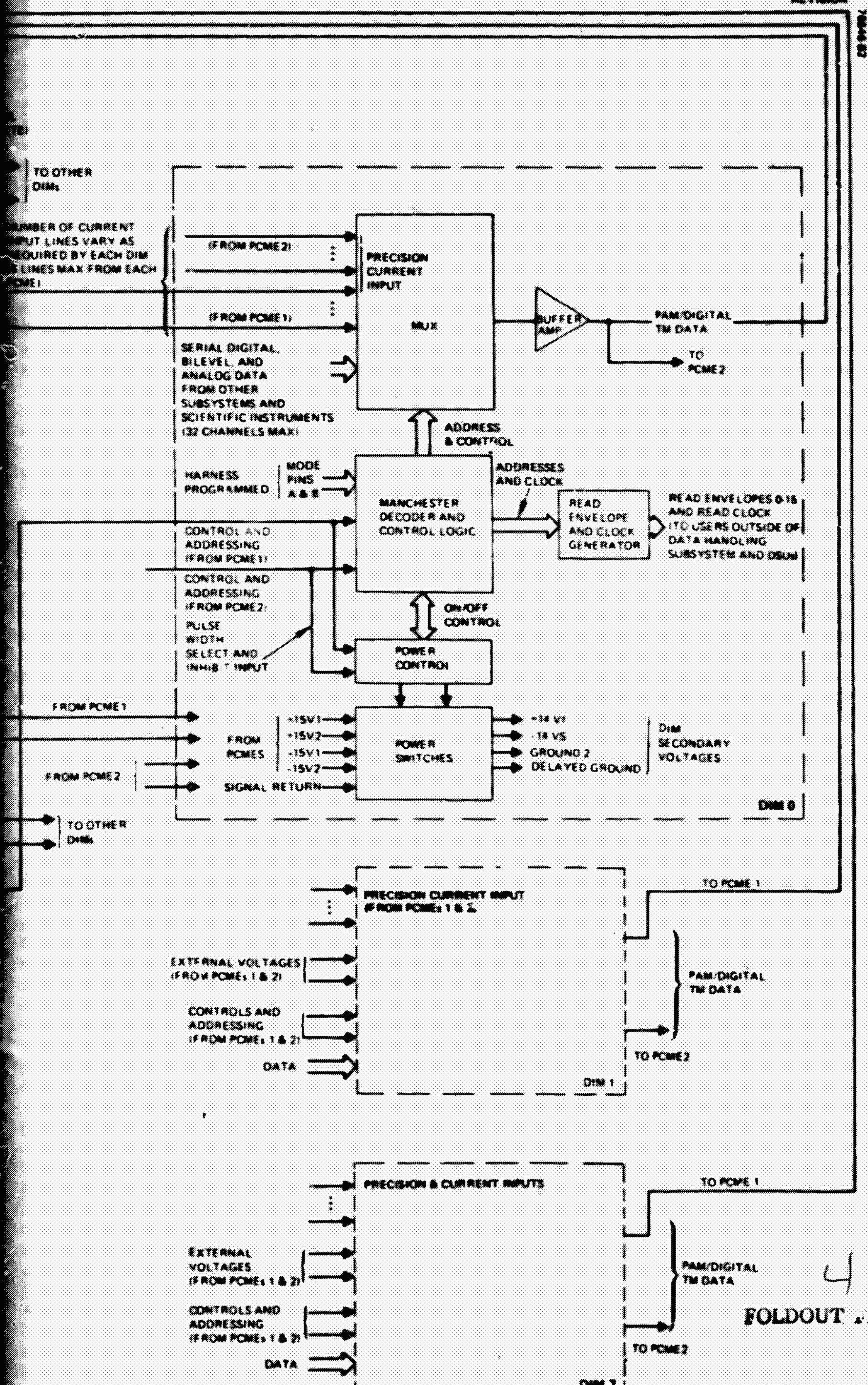

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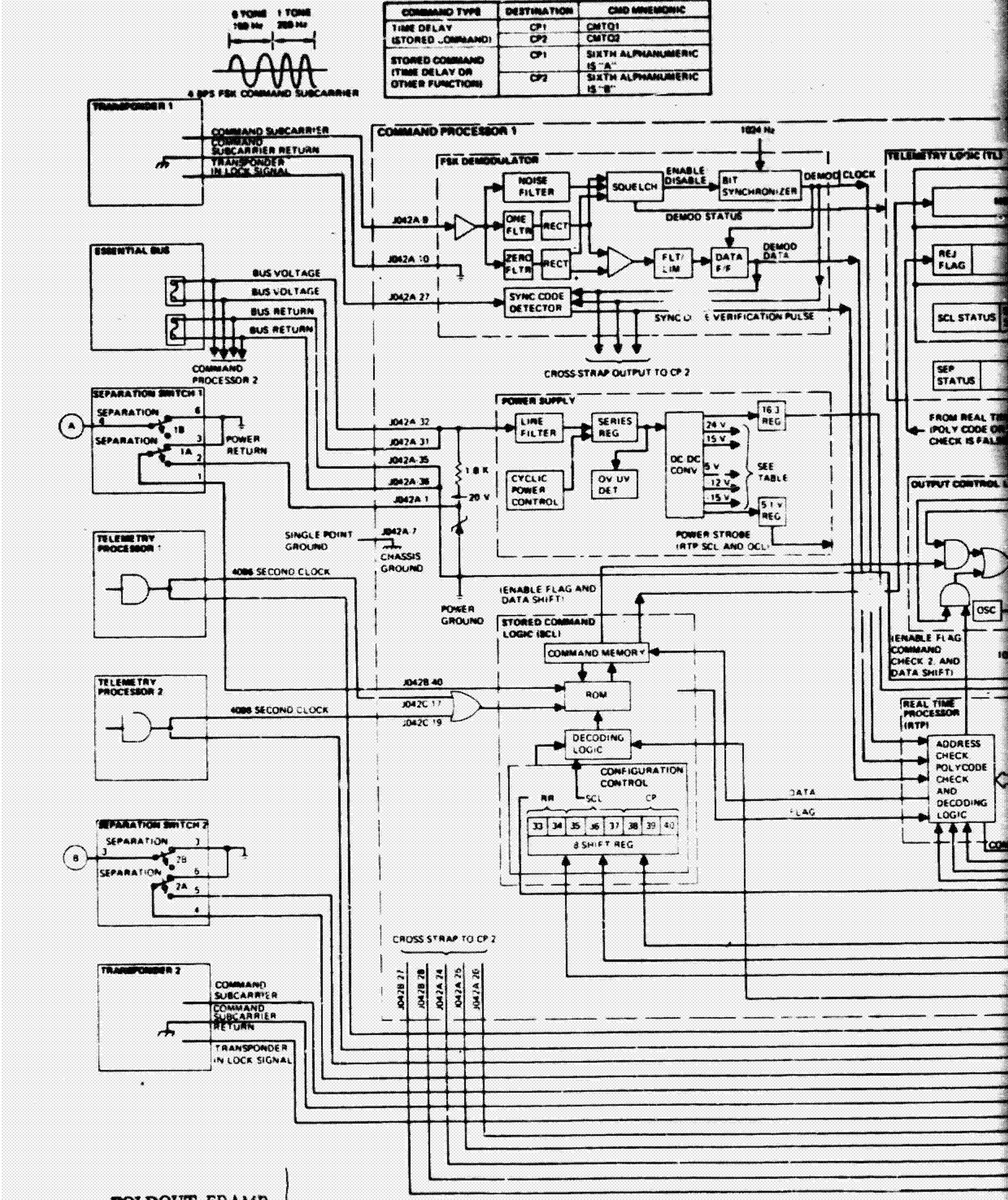
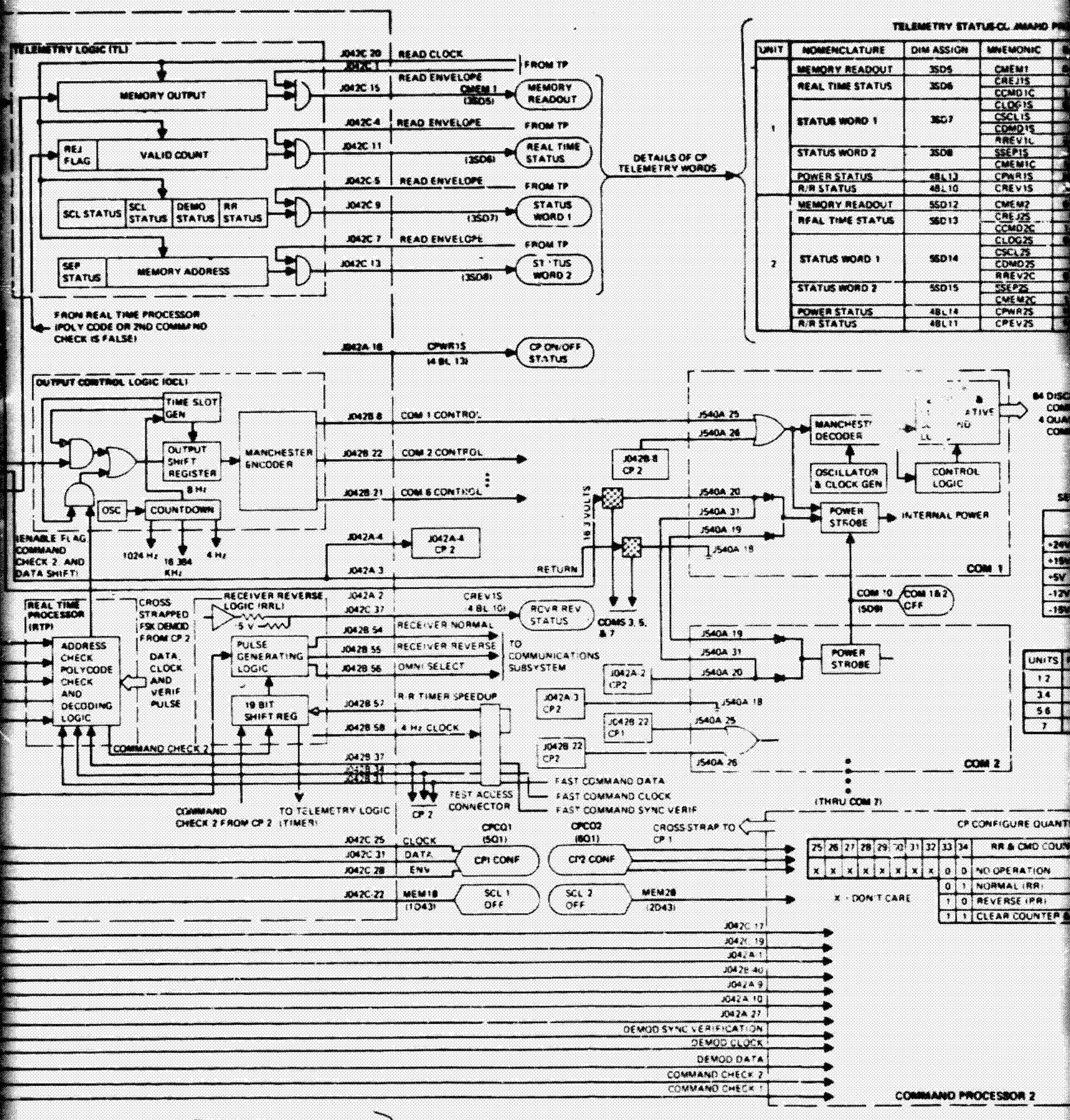
SHEET NO. C-13/C-14

FIGURE 3.5.1-1. MULTIPROBE BUS DATA HANDLING SUBSYSTEM COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM

COMMAND TYPE	DESTINATION	CMD MNEMONIC
TIME DELAY (STORED COMMAND)	CP1	CMTQ1
	CP2	CMTQ2
STORED COMMAND (TIME DELAY OR OTHER FUNCTION)	CP1	SIXTH ALPHANUMERIC IS "A"
	CP2	SIXTH ALPHANUMERIC IS "B"





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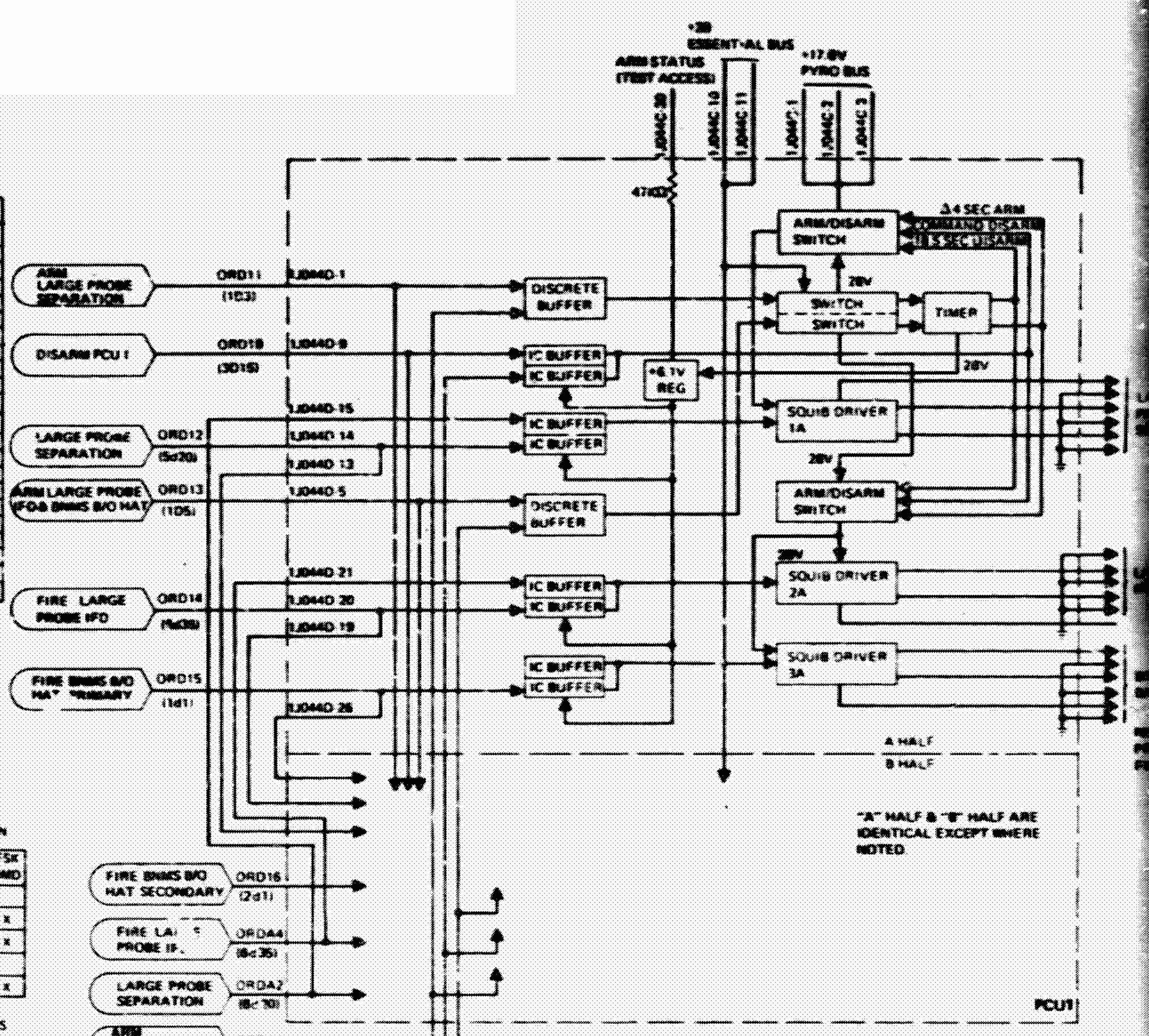
COMMAND PROCESSOR

MNEMONIC	BITS	TELEMETRY DESCRIPTION
MEM1	0–7	MEMORY CONTENTS
REJ1S	0	COMMAND REJECT
CMD1C	1–7	COMMAND COUNTER
LOG1S	0–3	SCL STATES
SCL1S	4	SCL ON/OFF STATUS
DMD1S	5	DEMOD SQUELCH STATUS
REV1C	6–7	RCVR REV TIMER
SEP1S	0	SEPARATION STATUS
MEM1C	1–7	ADDRESS POINTER
PWR1S	N/A	CP POWER ON/OFF
REV1S	N/A	RCVR REV STATUS
MEM2	0–7	MEMORY CONTENTS
REJ2S	0	COMMAND REJECT
CMD2C	1–7	COMMAND COUNTER
LOG2S	0–3	SCL STATUS
SCL2S	4	SCL ON/OFF STATUS
DMD2S	5	DEMOD SQUELCH STATUS
REV2C	6–7	RCVR REV TIMER
SEP2S	0	SEPARATION STATUS
MEM2C	1–7	ADDRESS POINTER
PWR2S	N/A	CP POWER ON/OFF
REV2S	N/A	RCVR REV STATUS



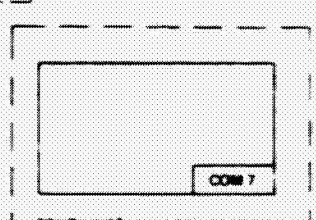
M DISCRETE COMMANDS
4 QUANTITATIVE COMMANDS

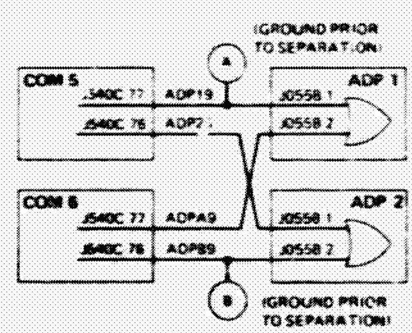
COMMAND PROCESSOR
SECONDARY VOLTAGES UTILIZATION

	SCL	RTP	OCL	RRL	TL	FSK DMD
+24V			X			
+15V			X		X	X
+5V	X	X	X	X	X	X
-12V	X					
-15V						X

COM OFF COMMAND DESCRIPTIONS

UNITS	REF DESIG	MNEMON	CMD DESCRIPTION
1 2	5D9	COM 18	COMS 1 & 2 OFF
3 4	1D34	COM 38	COMS 3 & 4 OFF
5 6	3D0	COM 58	COMS 5 & 6 OFF
7	8Dn	LCM18	COM 7 OFF





ADP ON COMMAND CONFIGURATION

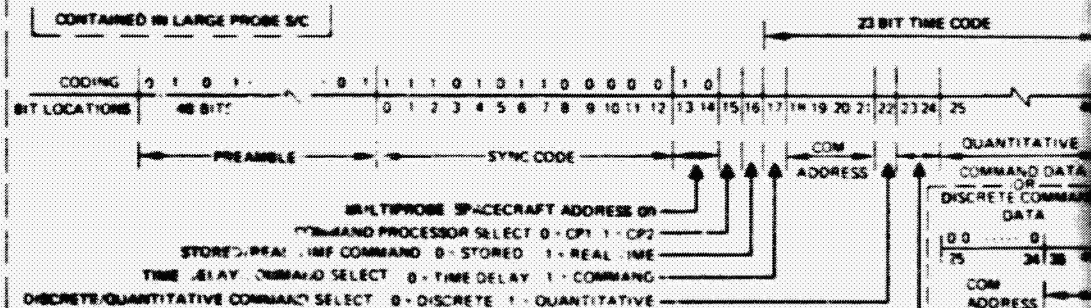
ADP ON COMMAND

UNIT	REF DESIG	MNEMONIC	ST
1	5D28	ADP19	GR BEF
	6D28	ADPA9	UNG
2	5D31	ADP29	UNG
	6D31	ADPB9	GR BEF

FIGURE QUANTITATIVE COMMAND CODING

& CMD COUNTER	35	36	37	38	SCL	39	40	SELECT CP
ERATION	0	0	0	0	NO OPERATION	0	0	NEITHER
AL (RR)	0	0	0	1	STANDBY	0	1	CP 1
SE (RR)	0	0	1	0	IMMED START	1	0	CP 2
COUNTER & FLAG	0	0	1	1	TIMED START	1	1	EITHER
	0	1	0	0	LOAD			
	0	1	0	1	ADVANCE			
	0	1	1	0	STOP			
	0	1	1	1	ARM SEP SW			
	1 1	0 0	0 0	0 1	CLEAR ON			
	1 1	0 0	1 1	0 1	INDEX			
	1 1	1 1	0 0	0 1	READ			
	1 1	1 1	1	0 1	OFF			

OR 2



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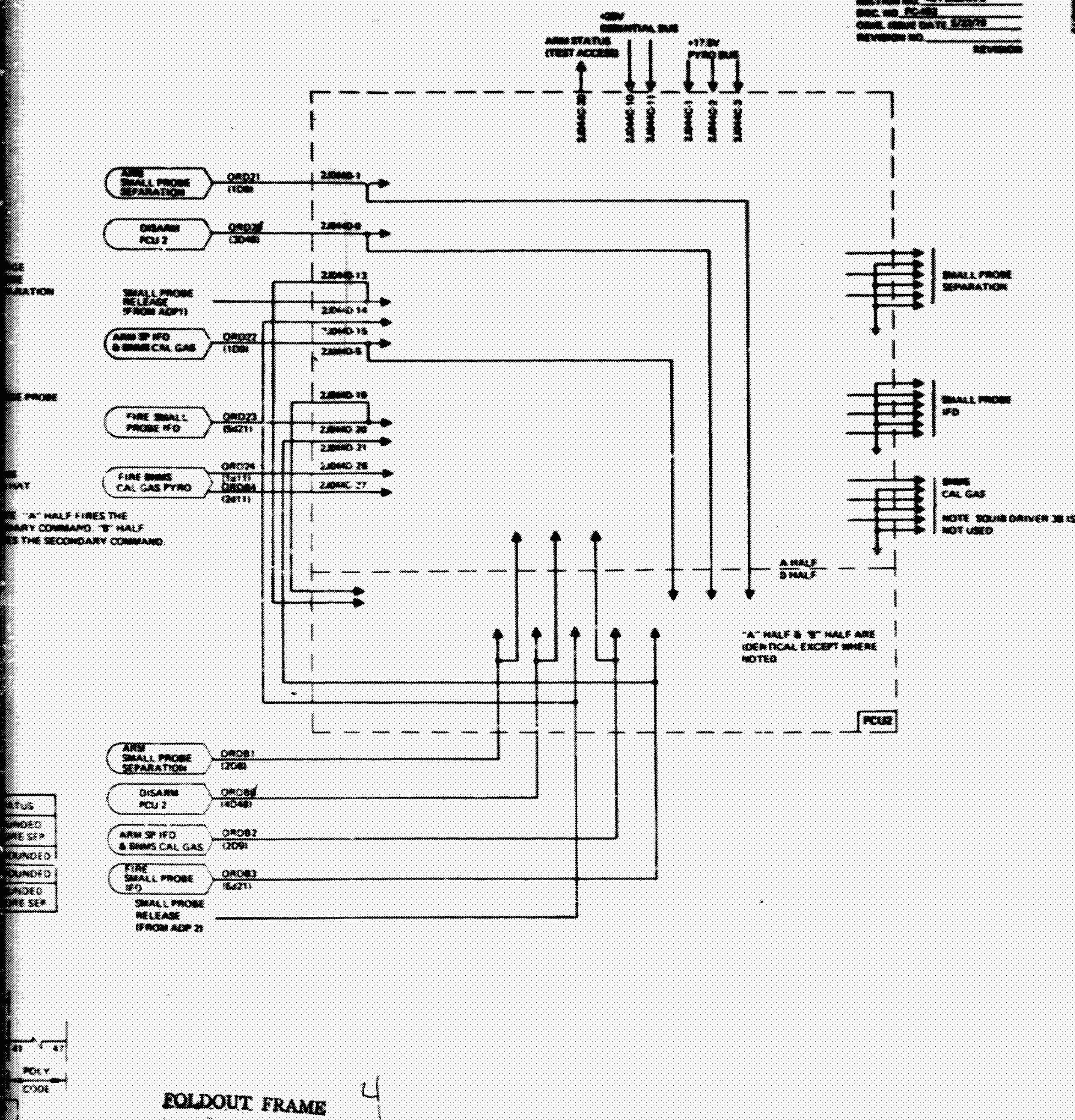

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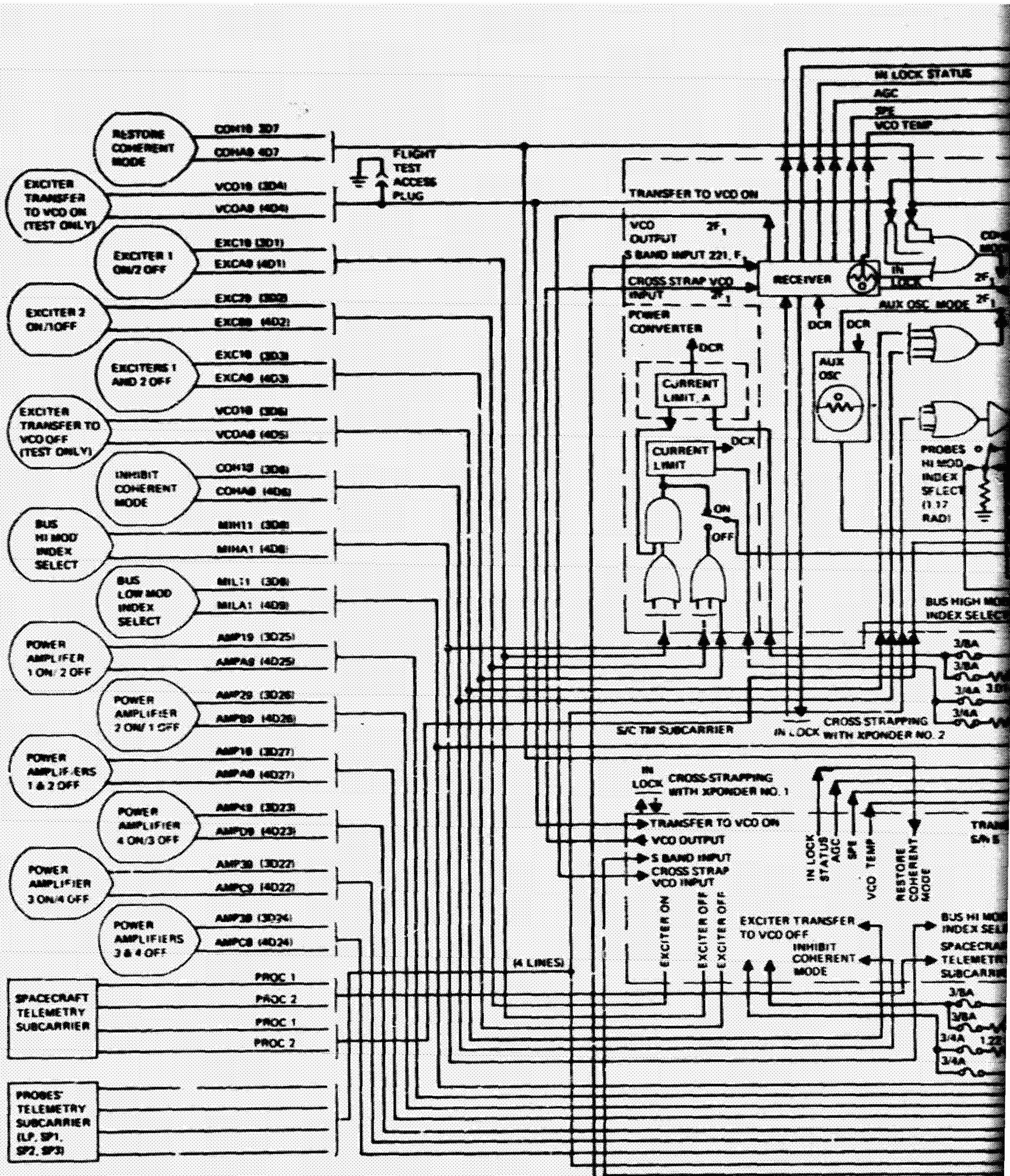
FIGURE 3.8.1-1 MULTIPROBE BUS COMMAND SUBSYSTEM COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM SHEET NO. C-15/C-16



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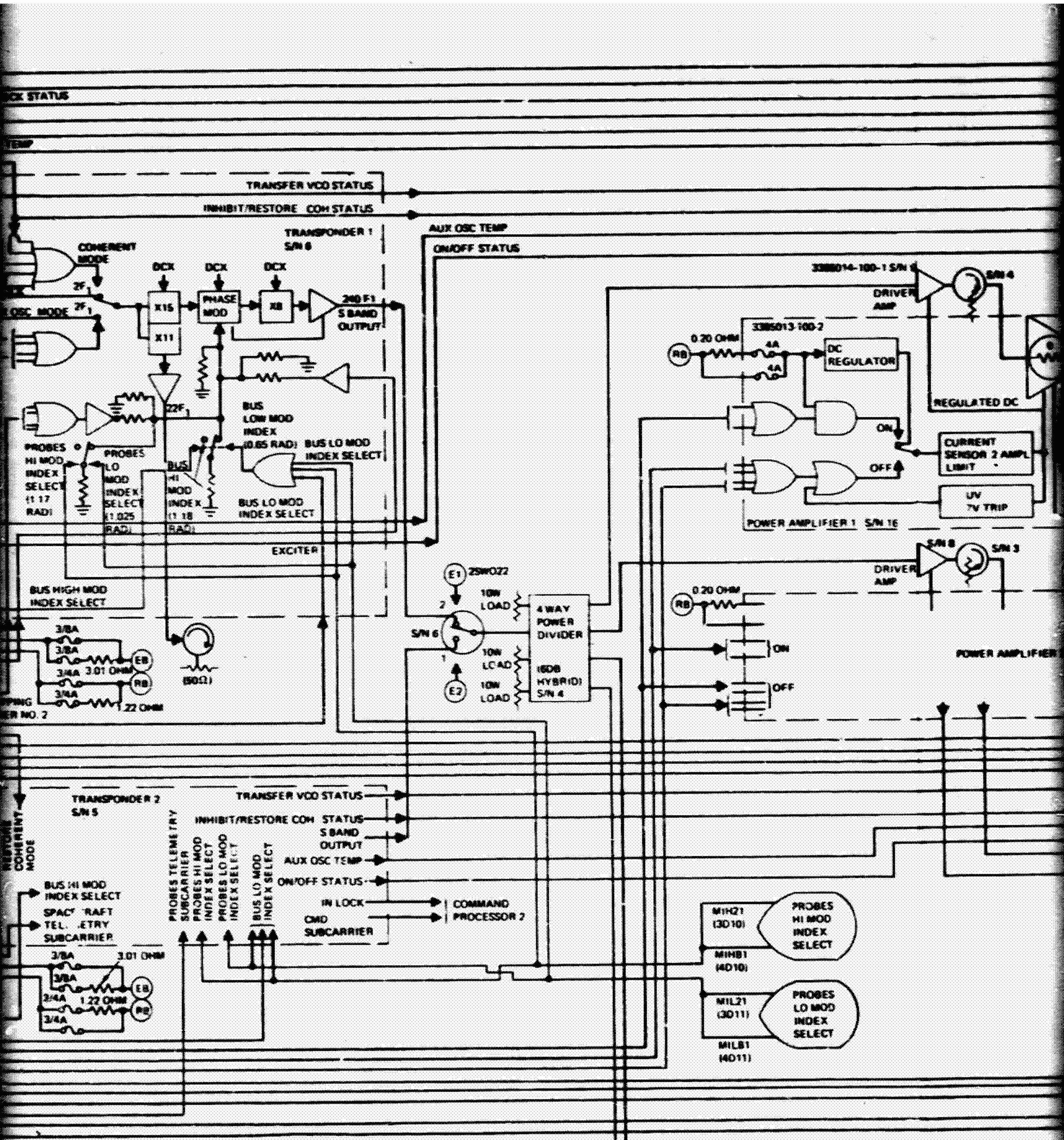

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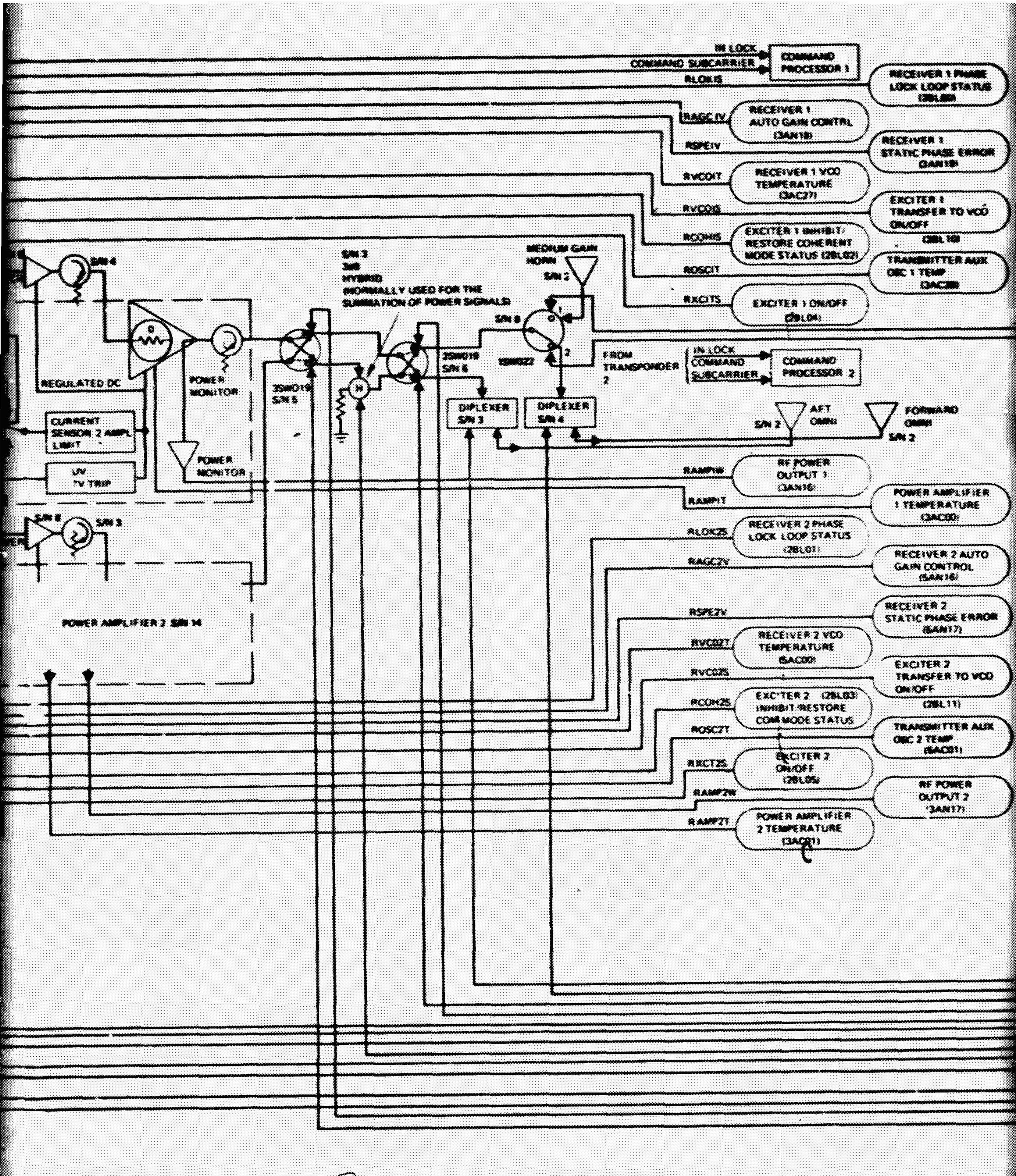

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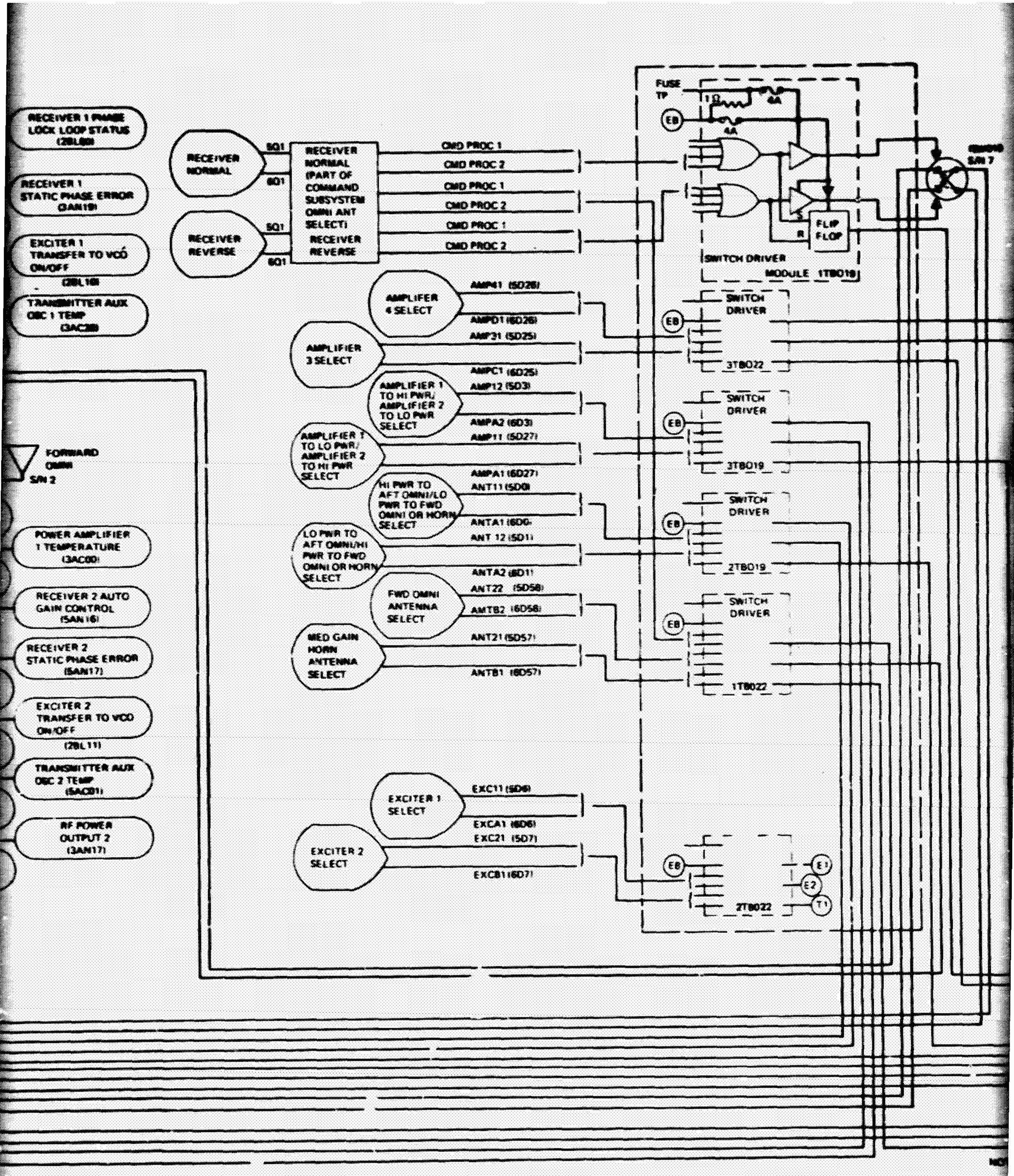

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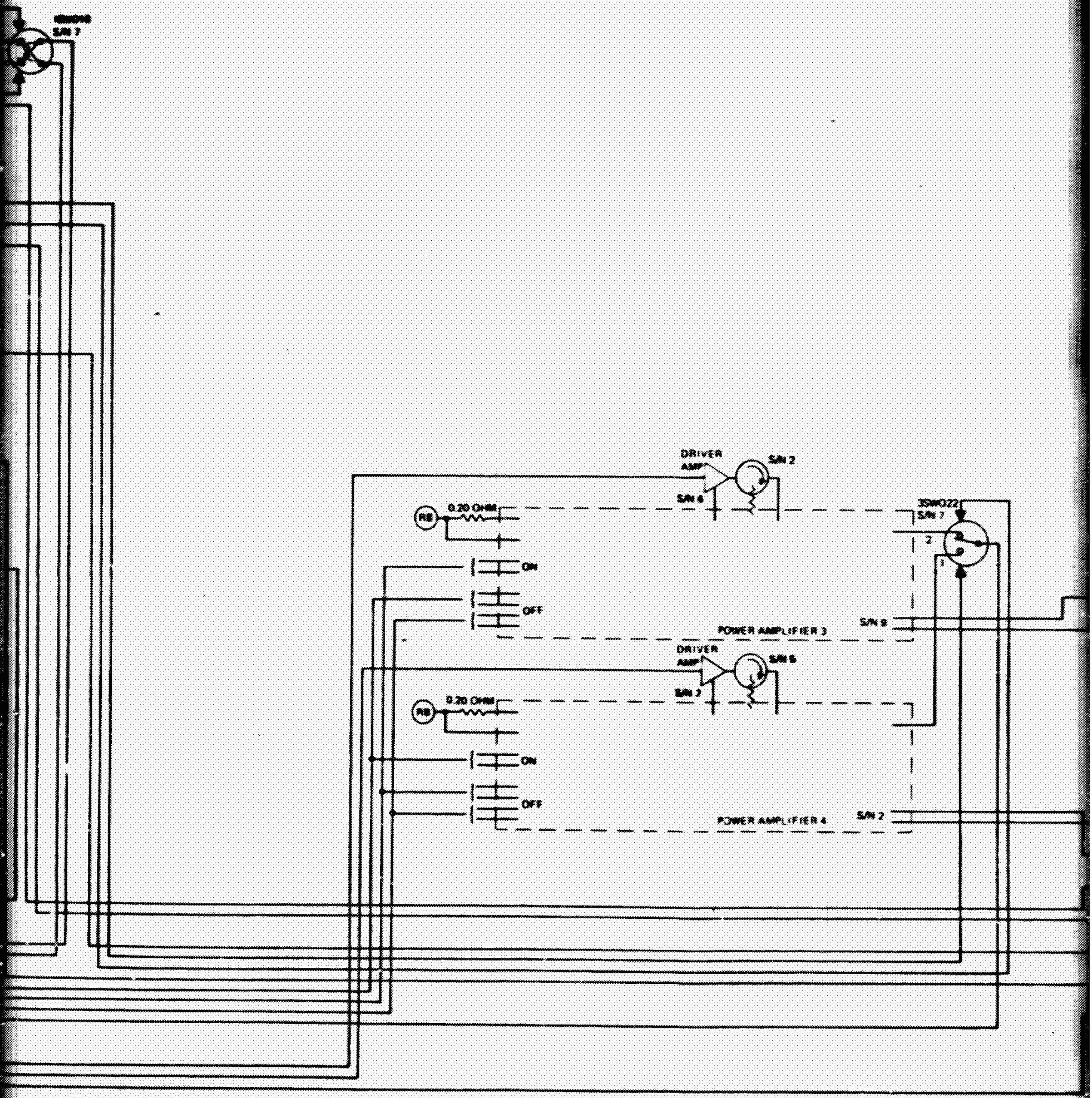

NOTES: (A) FOR DPDT SWITCHES
THE "2" POSITION IS SHOWN
AS SOLID LINES. THE "1"
POSITION IS SHOWN AS DASHED LINES.

(B) EB — SPACECRAFT ESSENTIAL BUS
RB — SPACECRAFT RF BUS

FIGURE 3.7.1-4.
COMMAND

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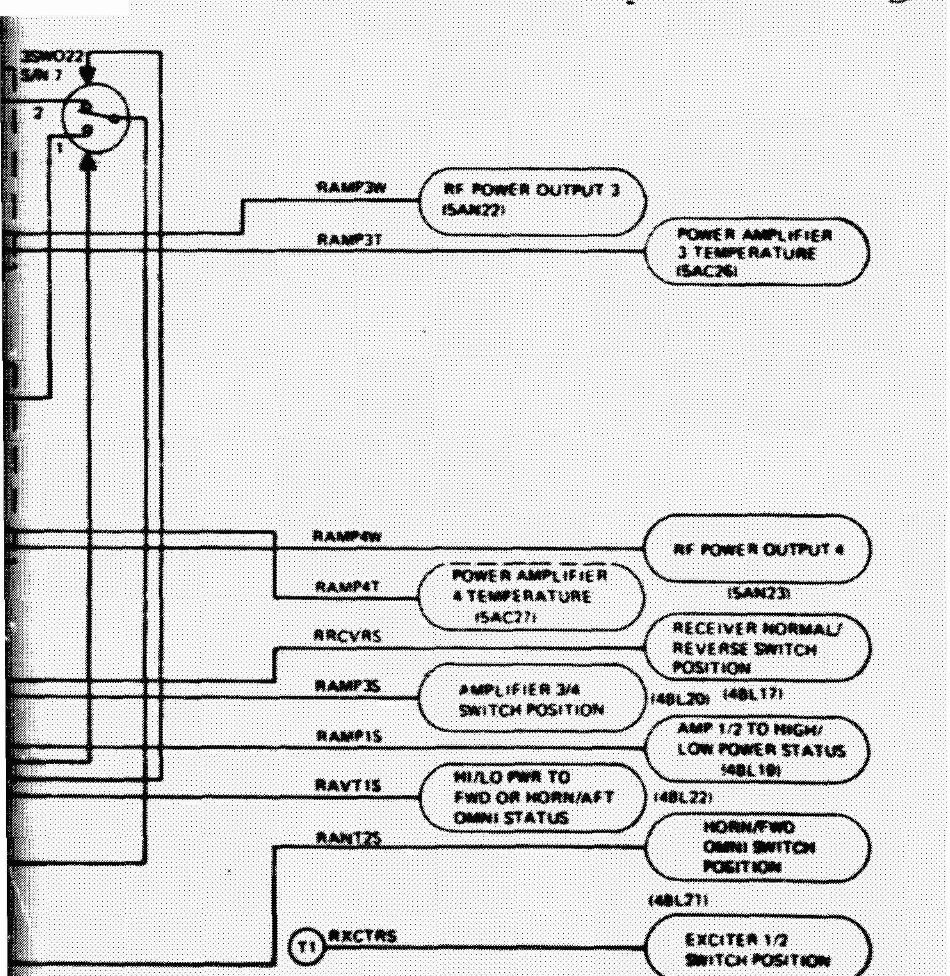
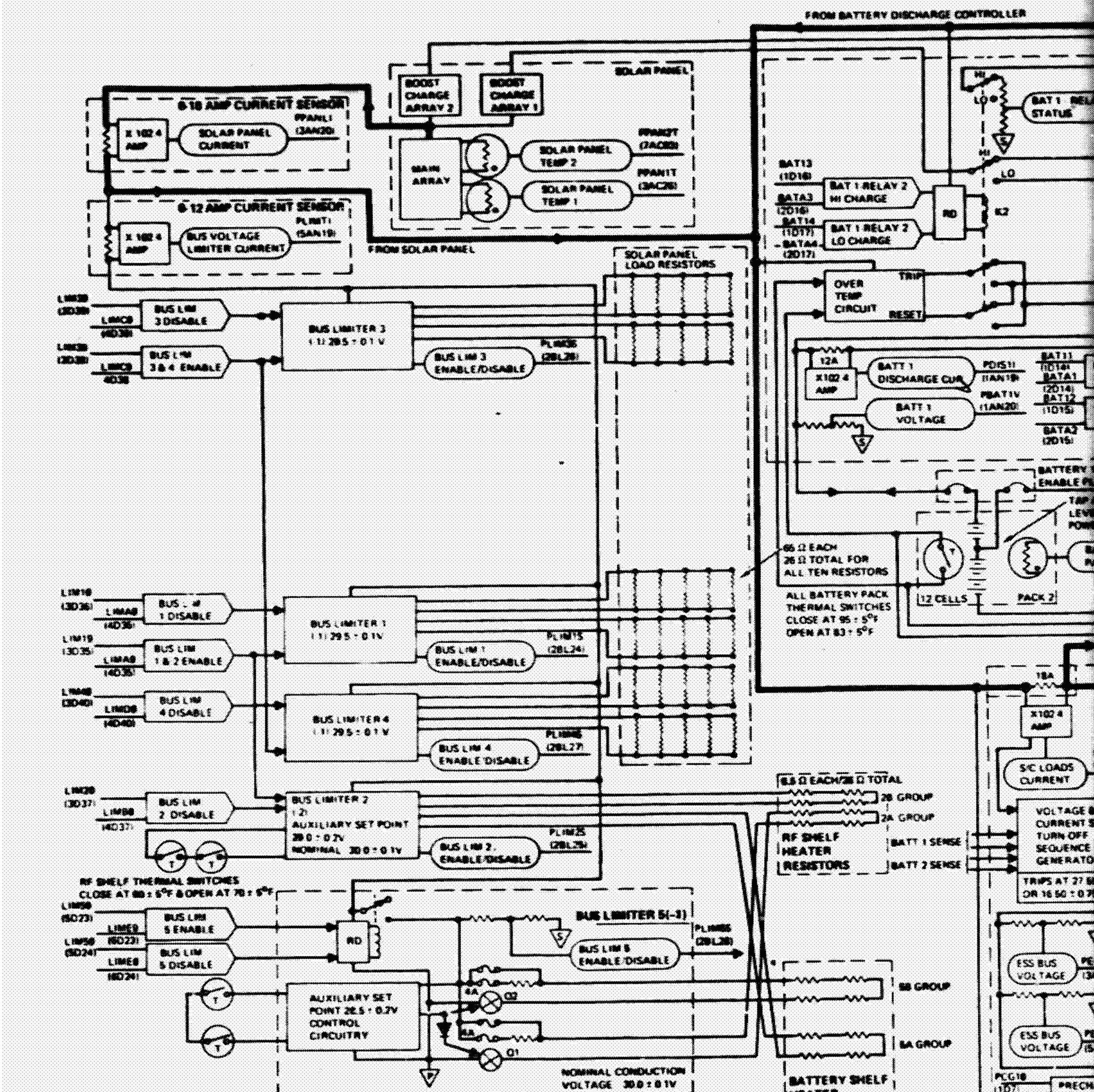


FIGURE 2.7.1-4. MULTIPROBE BUS COMMUNICATION SUBSYSTEM COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM SHEET NO. C-17/C-18



NOTE 1: ALL RELAYS ARE LATCHING TYPE WITH 2 COILS. ONE COIL DRIVES CONTACTS UPWARDS AND SECOND COIL DRIVES CONTACTS DOWNWARD, EXCEPT FOR PROBES. DIAGRAM SHOWS ONLY ONE OF TWO COILS

NOTE 2: ALL PROBE TM SIGNALS SHOWN HERE ROUTED THRU IFD TO BUS DIM UNITS

NOTE 3: ALL TEMPERATURE SENSOR RETURNS REFERENCED TO SIGNAL RETURN

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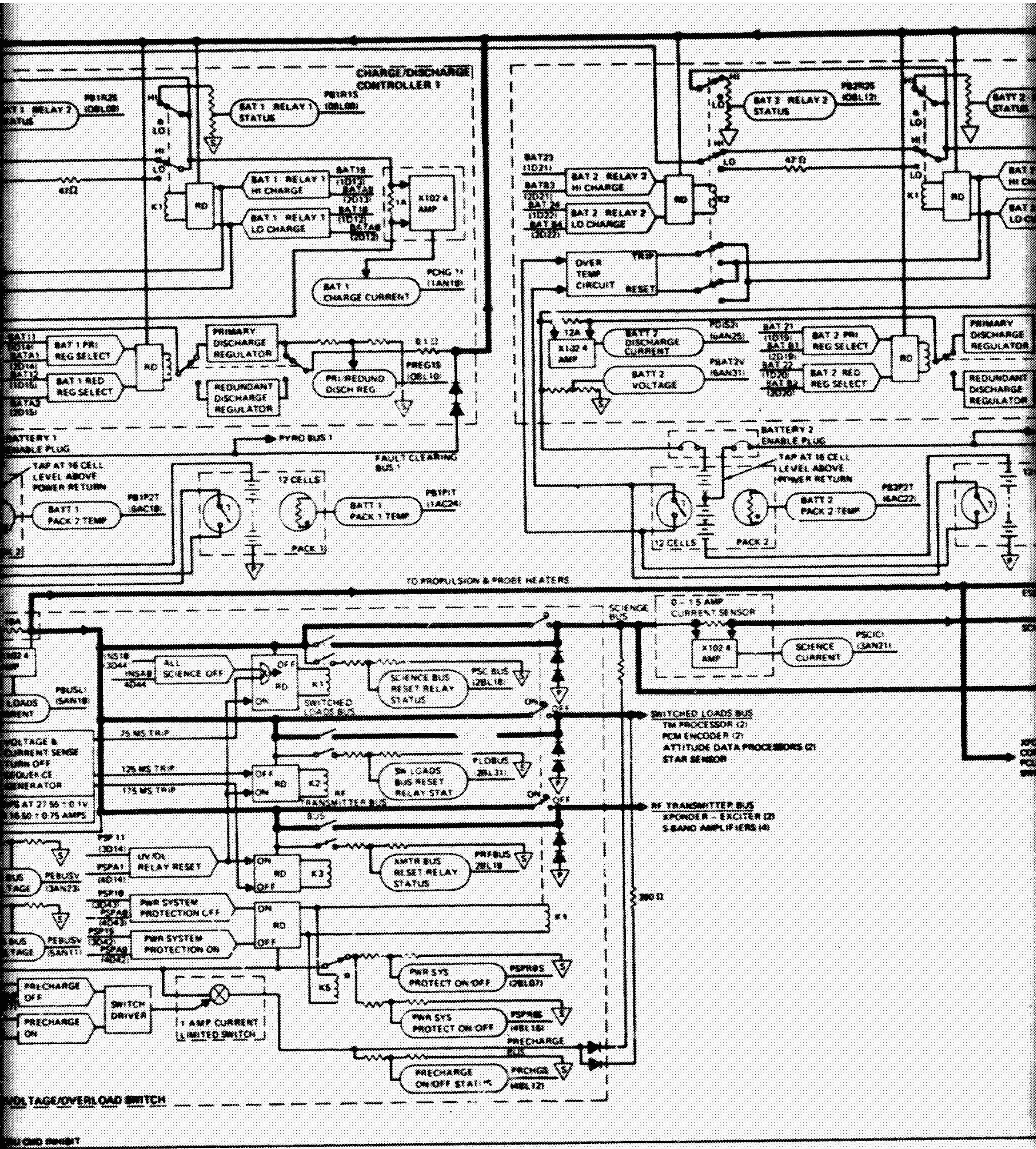

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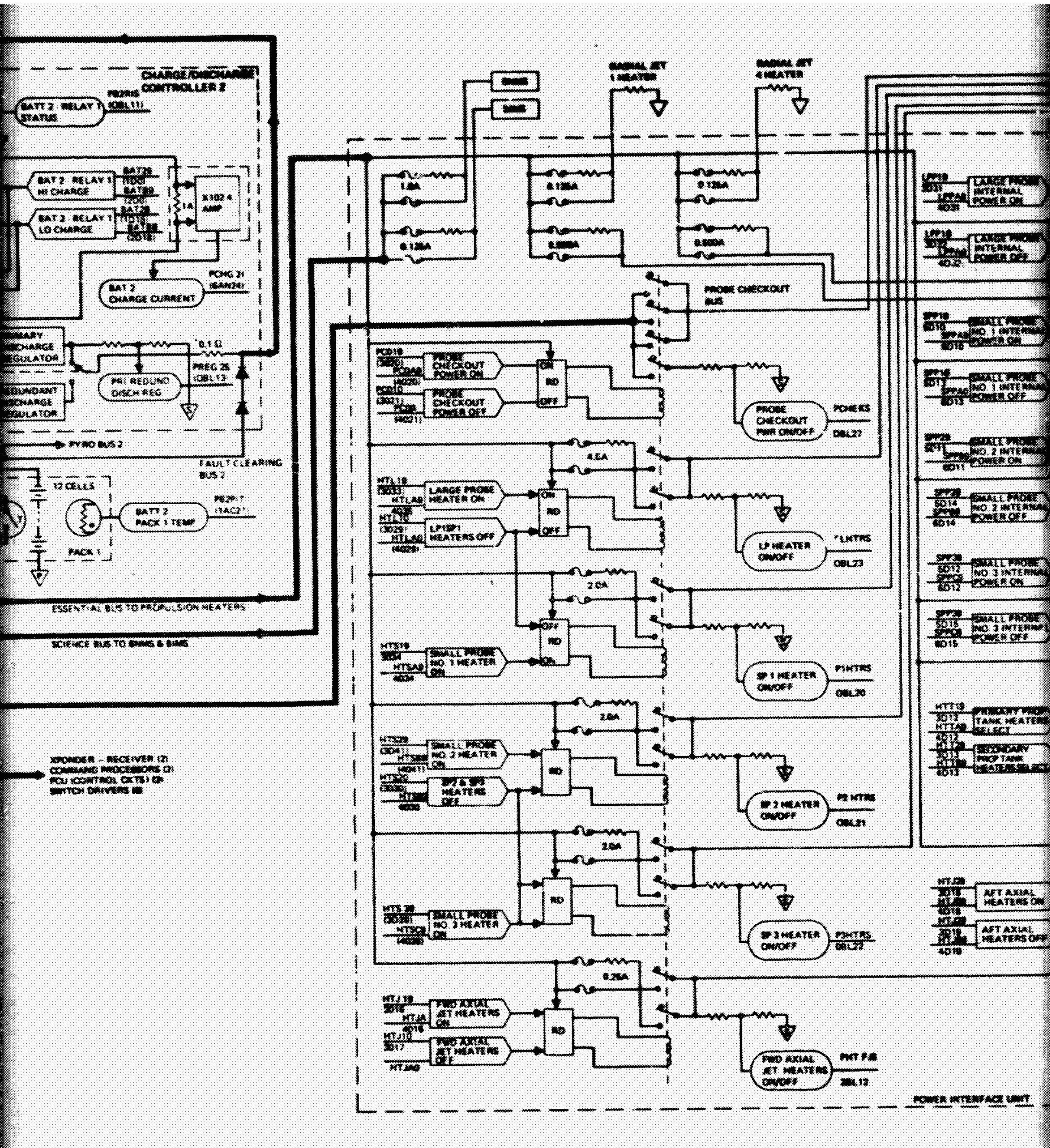

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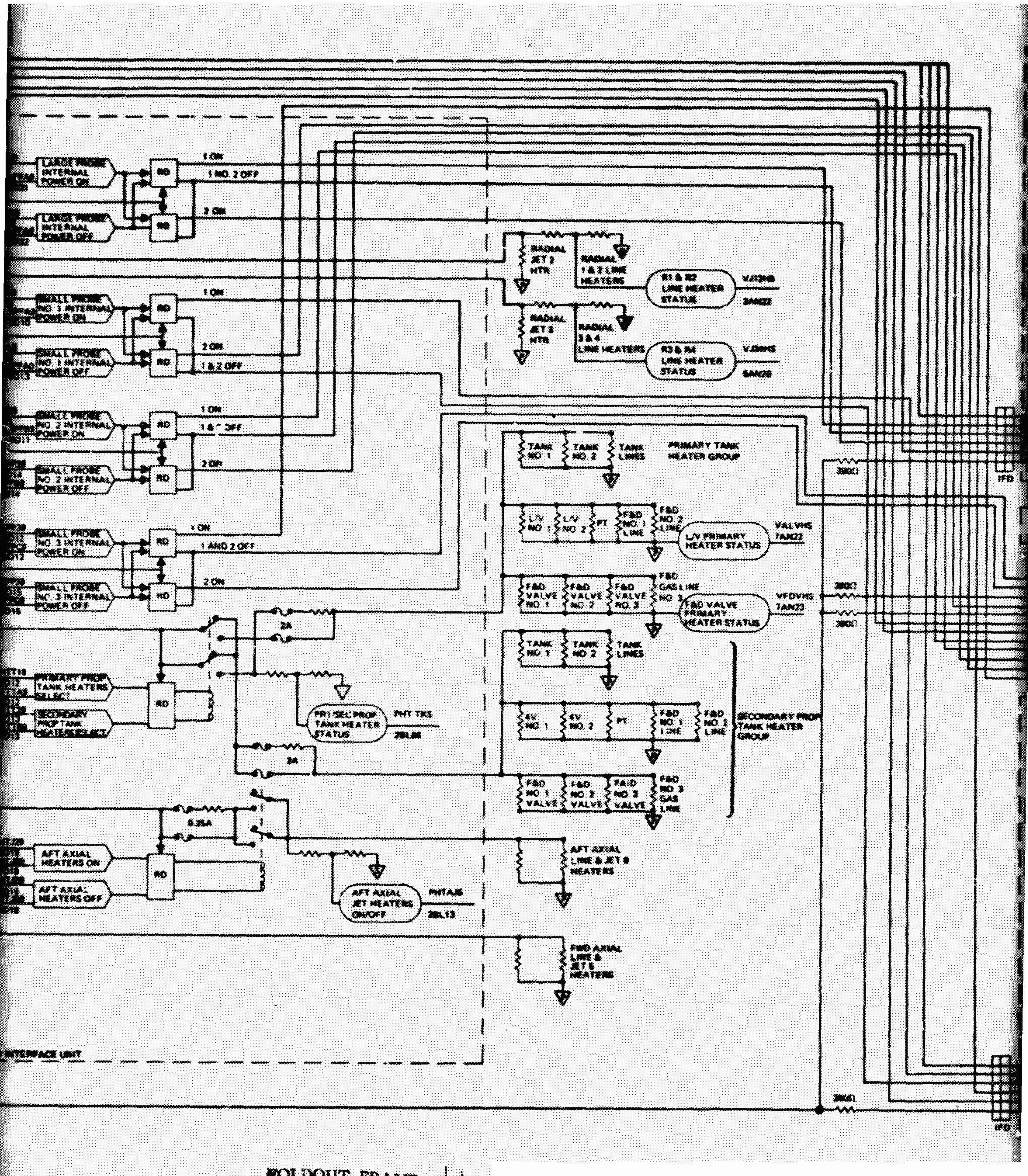

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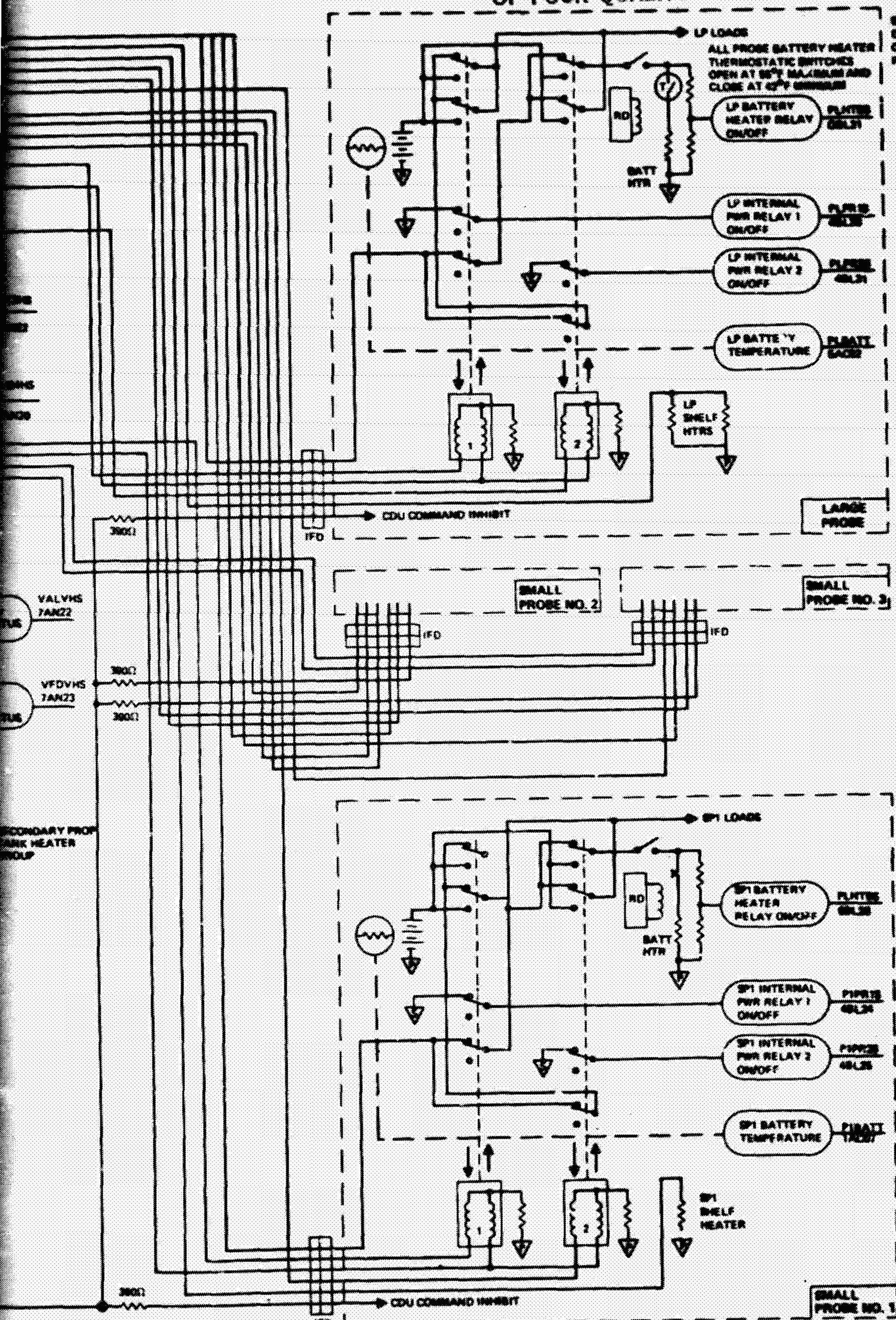
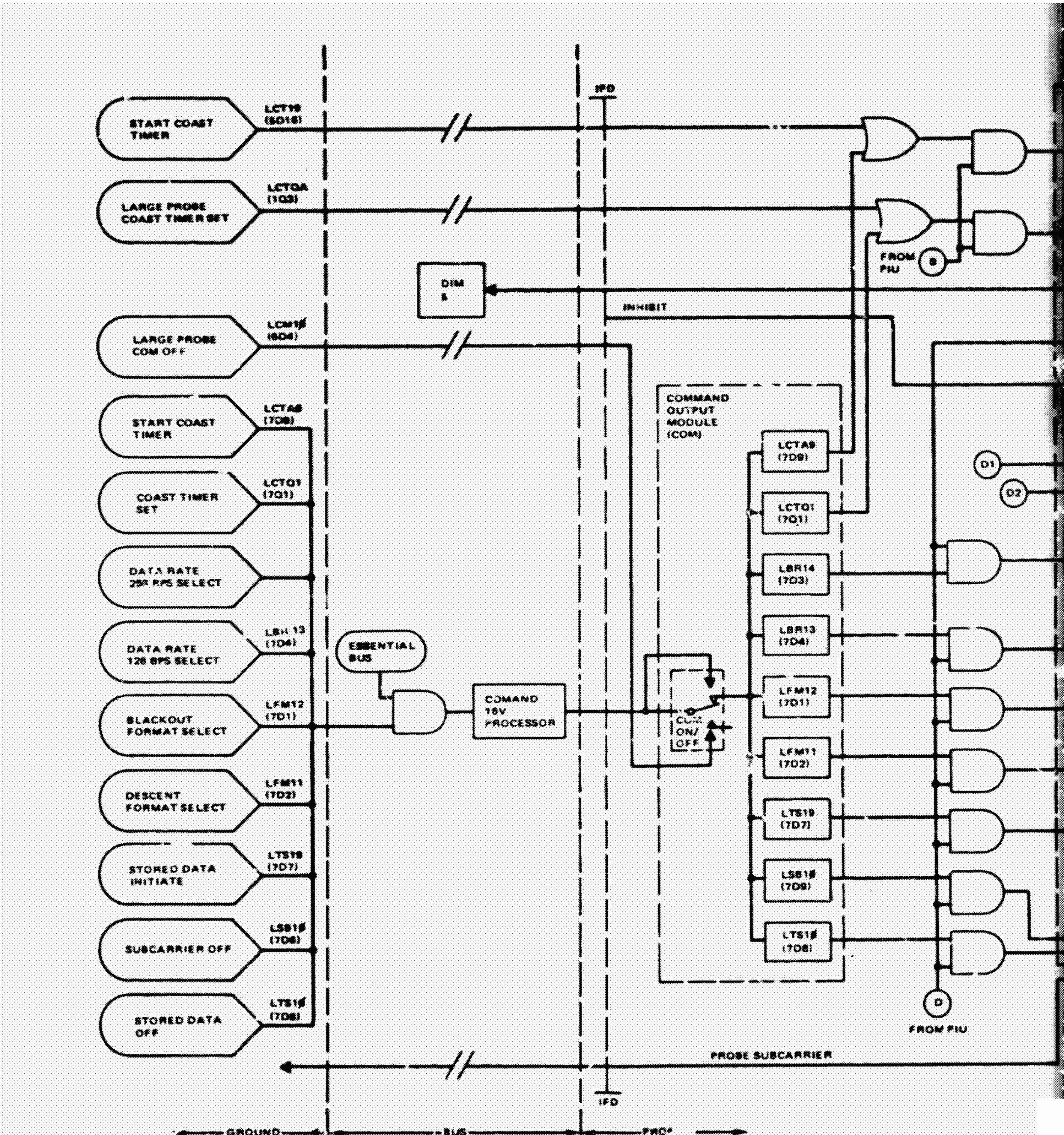


FIGURE 3.8.1-1. MULTIPROBE POWER SUBSYSTEM COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM



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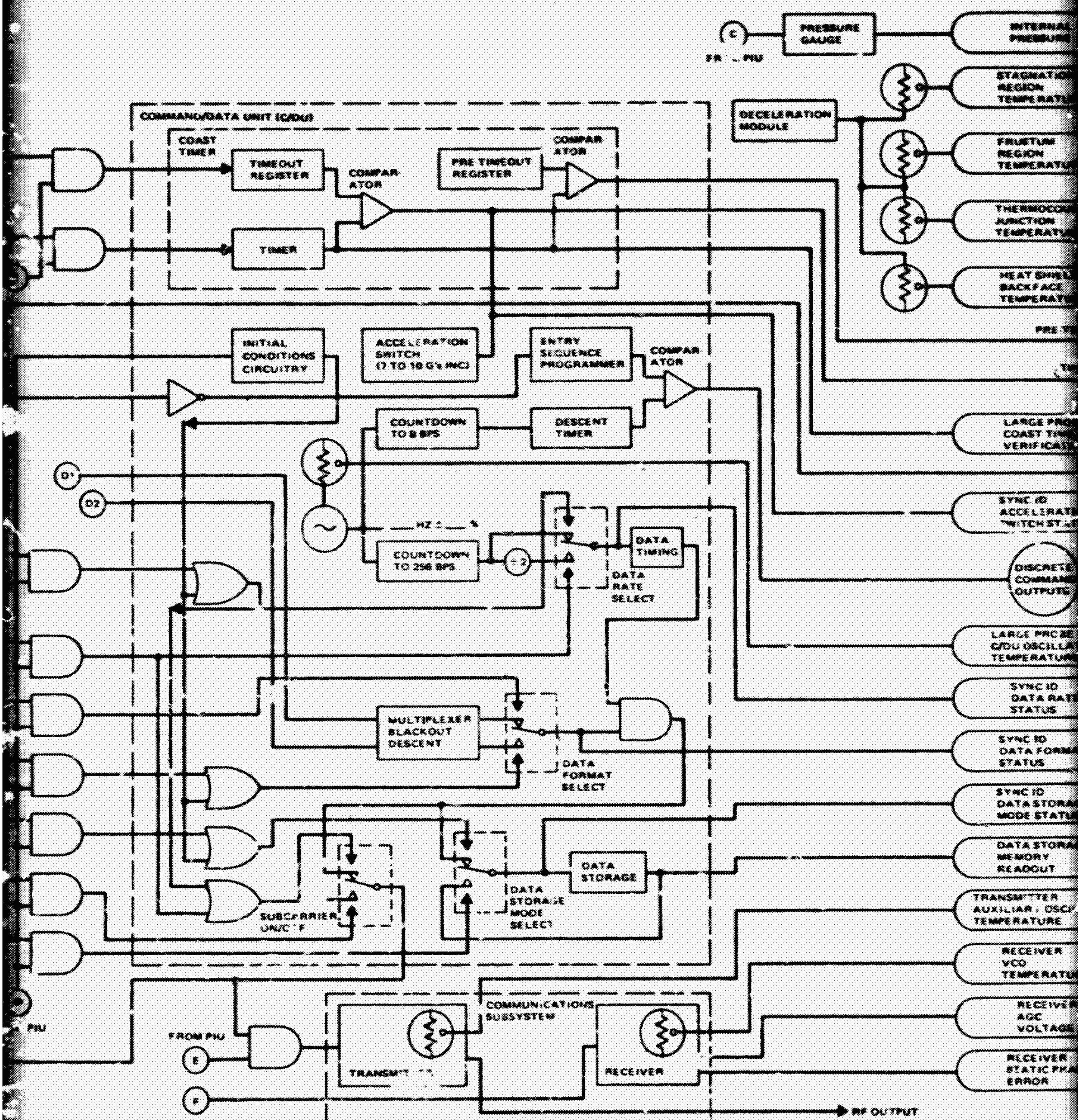

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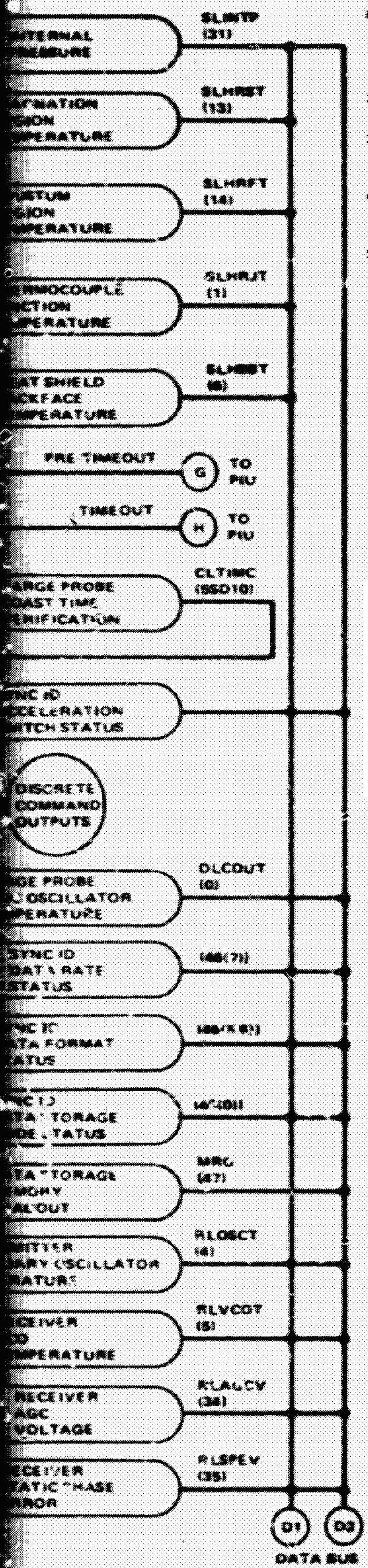
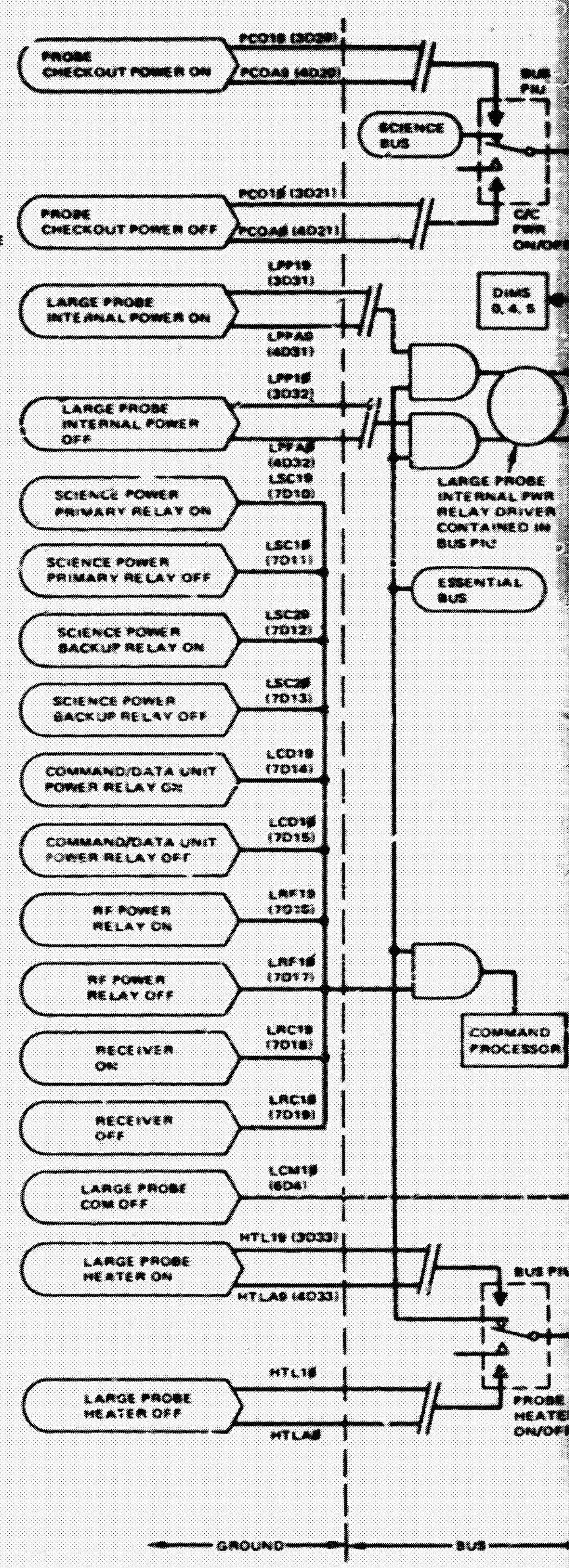


NOTES:

1) ALL UNITS OPERATE DIRECTLY OFF POWER BUSES B C D E OR F. ADDITIONAL POWER CONVERSION IS ACCOMPLISHED WITHIN UNITS.
2) 14 COMMANDS FROM BUS TO SCIENTIFIC INSTRUMENTS ARE NOT SHOWN.
3) D1 REPRESENTS BLACKOUT DATA BUS WHICH INCLUDES SCIENTIFIC INSTRUMENT DATA FROM LAS AND LN. (8 CHANNELS)
4) D2 REPRESENTS DESCENT DATA BUS WHICH INCLUDES SCIENTIFIC INSTRUMENT DATA FROM LAS, LN, LCPS, LIR, LNMS, LGC, AND LSFR. (16 CHANNELS)
5) ALL RELAYS ARE MAGNETIC LATCHING AND DO NOT CHANGE STATE WHEN DRIVER POWER IS TURNED OFF
6) ALL INDICATED VOLTAGES, CURRENTS, AND TEMPS ARE EXPECTED PERFORMANCE VALUES



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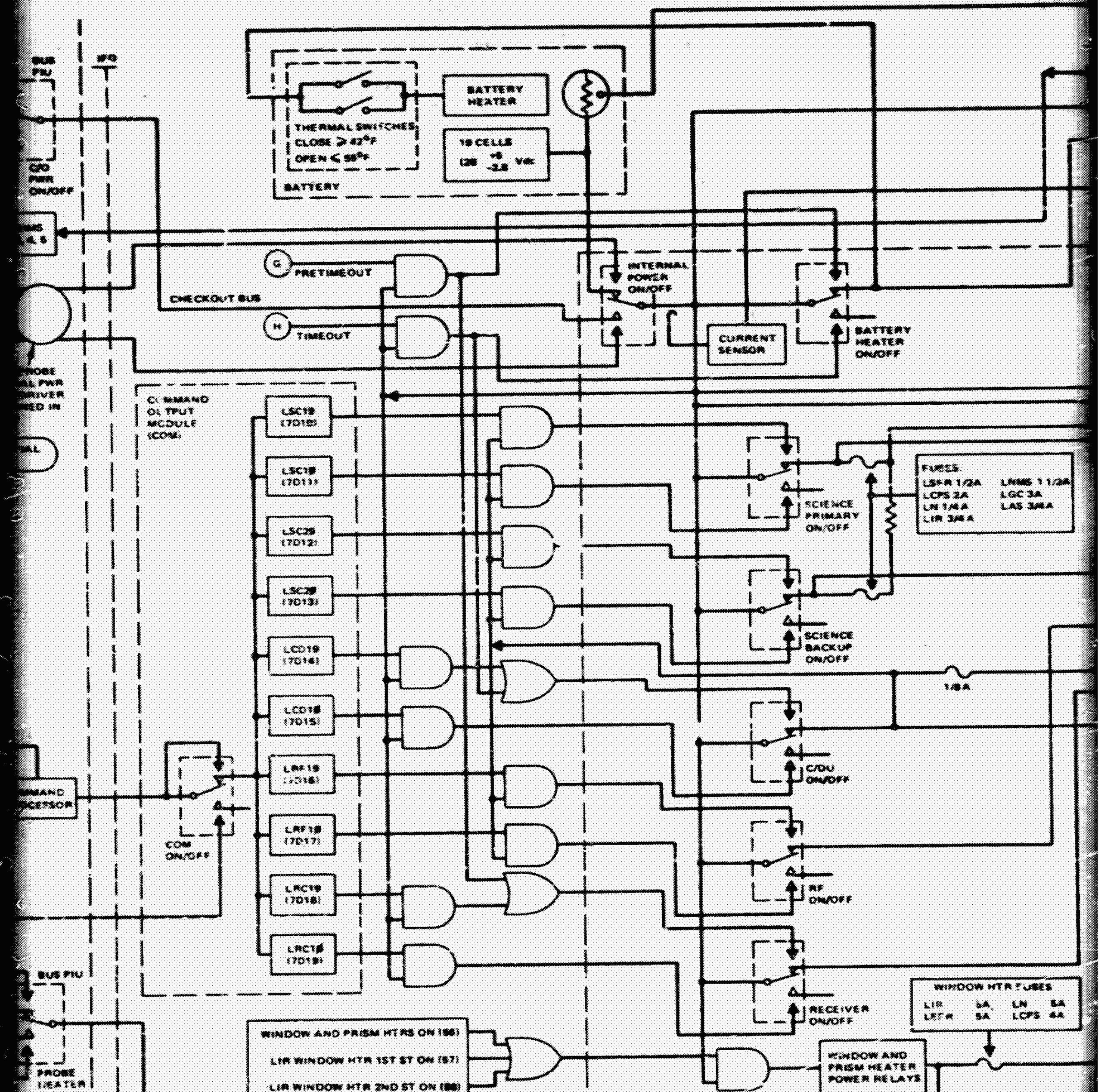

FIGURE 5.1.2.2-1.

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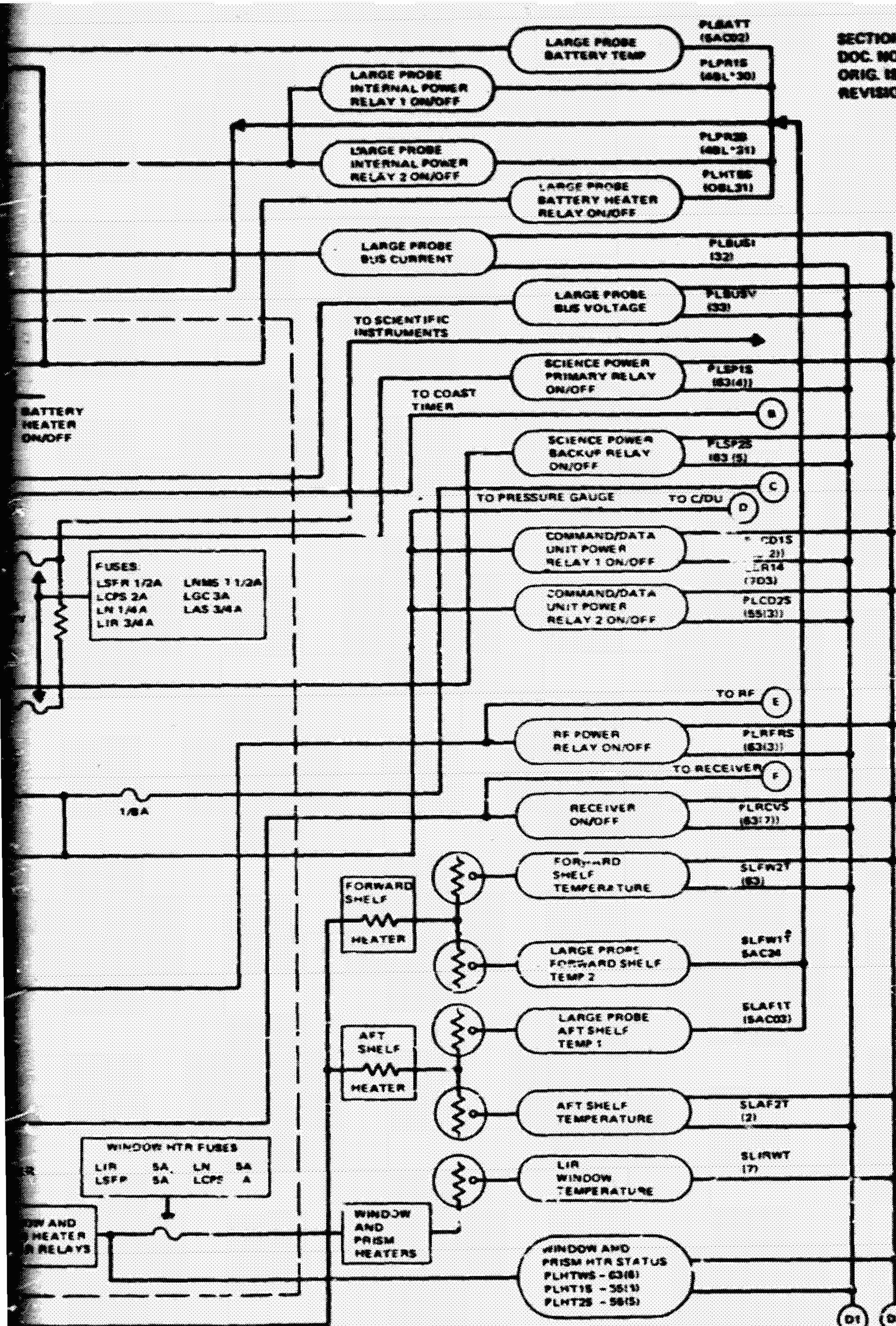
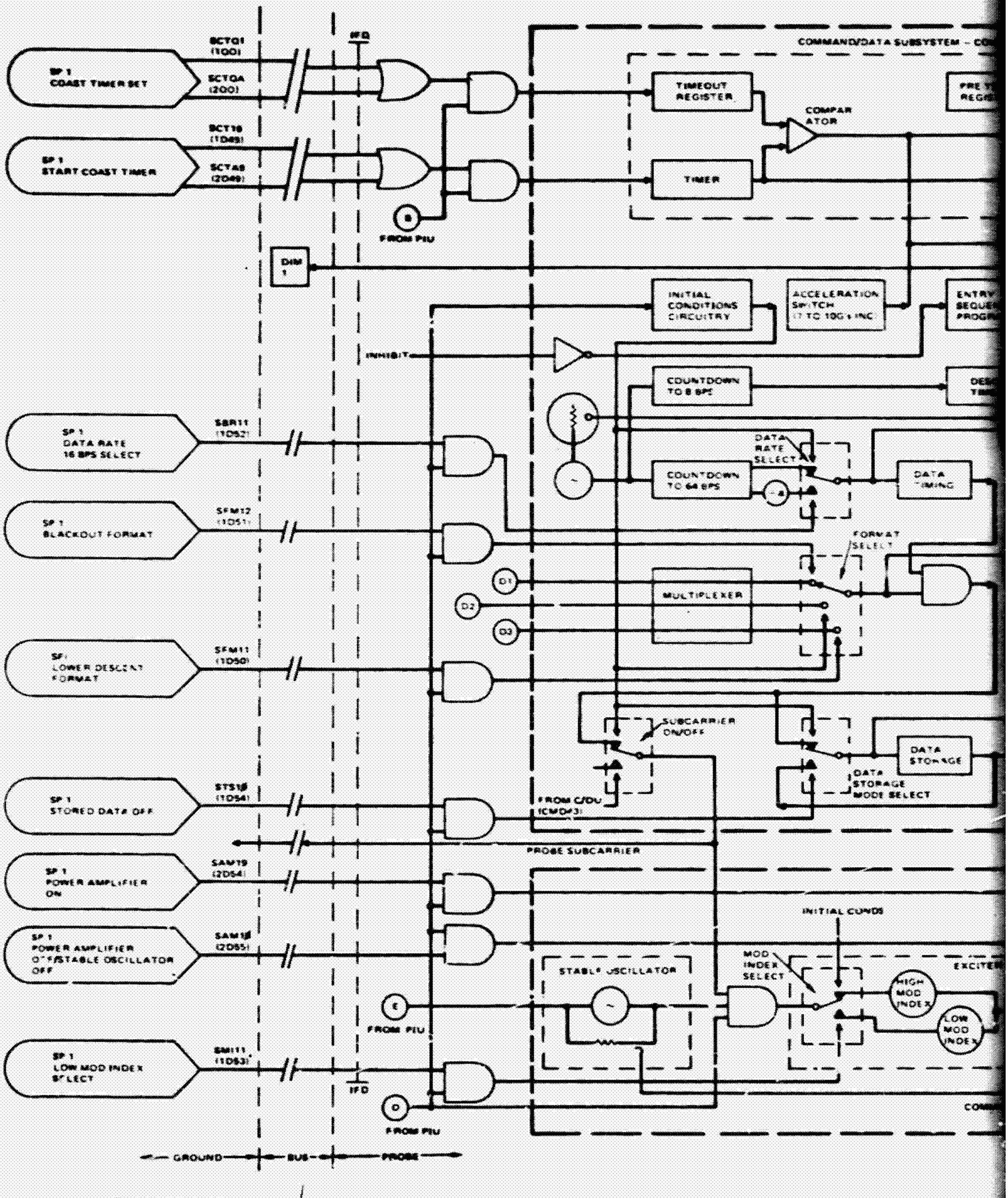


FIGURE 5.1.2.2-1. LARGE PROBE COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM

SHEET NO. C-21/C-22

FOLDOUT FRAME 5



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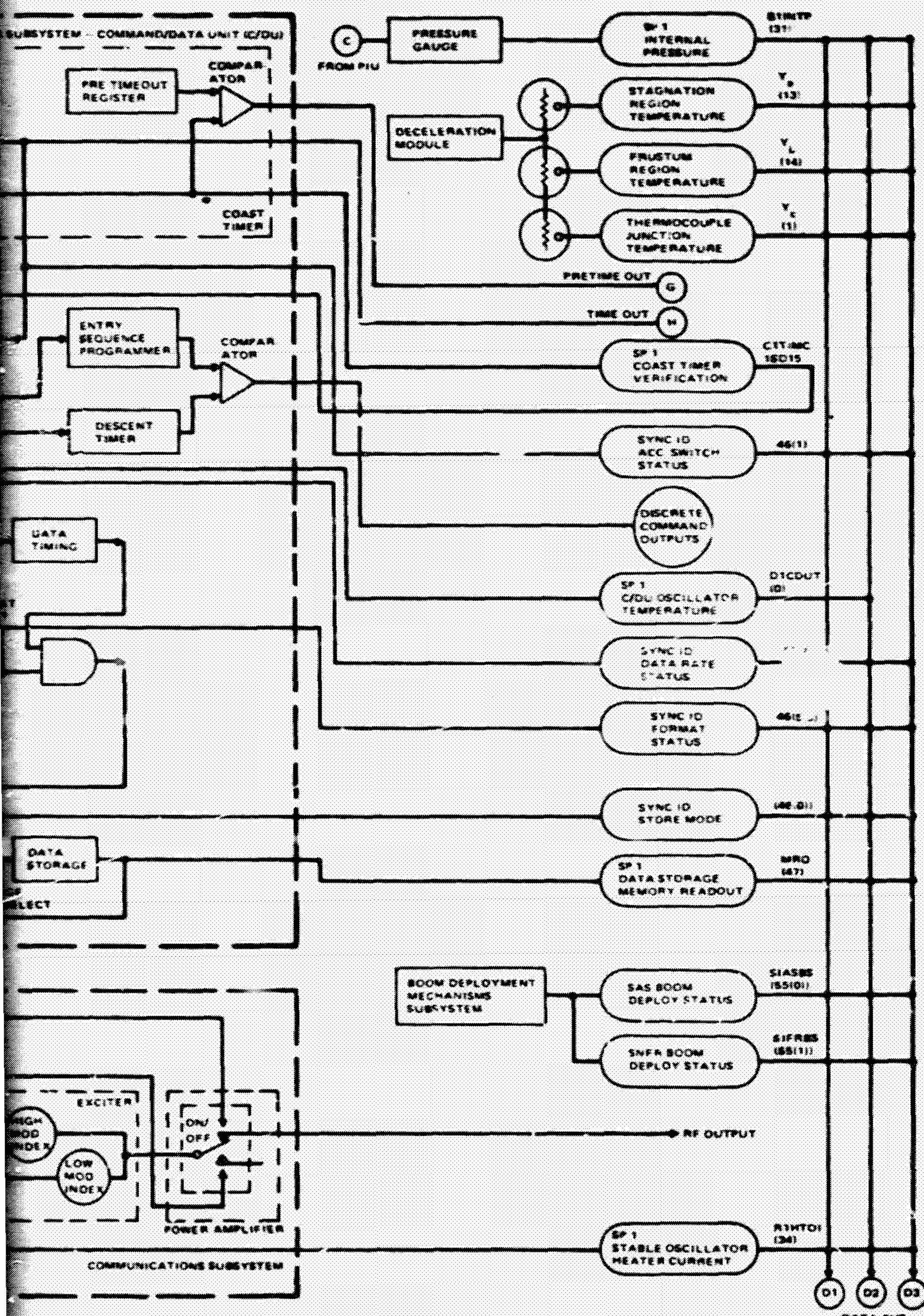
NOTE:

1) SMALL PROBE 2 AND 3 IDENTICAL EXCEPT FOR
2) ALL UNITS OPERATE DIRECTLY OFF POWER BUS
OR (E) ADDITIONAL POWER CONVERSION IS AC
WITHIN UNITS
3) 38 COMMANDS FROM BUS TO SCIENTIFIC INSTRU
ARE NOT SHOWN
4) (D1) REPRESENTS BLACKOUT DATA BUS WHICH IN
SCIENTIFIC INSTRUMENT DATA FROM SAS AND
(8 CHANNELS)
5) (D2) AND (D3) RESPECTIVELY REPRESENT UPPER A
DESCENT DATA BUS WHICH INCLUDES DATA FRO
AND SNFR (10 CHANNELS)
6) ALL RELAYS ARE MAGNETIC LATCHING AND DO
STATE WHEN DRIVER POWER IS TURNED OFF
7) ALL INDICATED VOLTAGES, CURRENTS, AND TE
ARE EXPECTED PERFORMANCE VALUES



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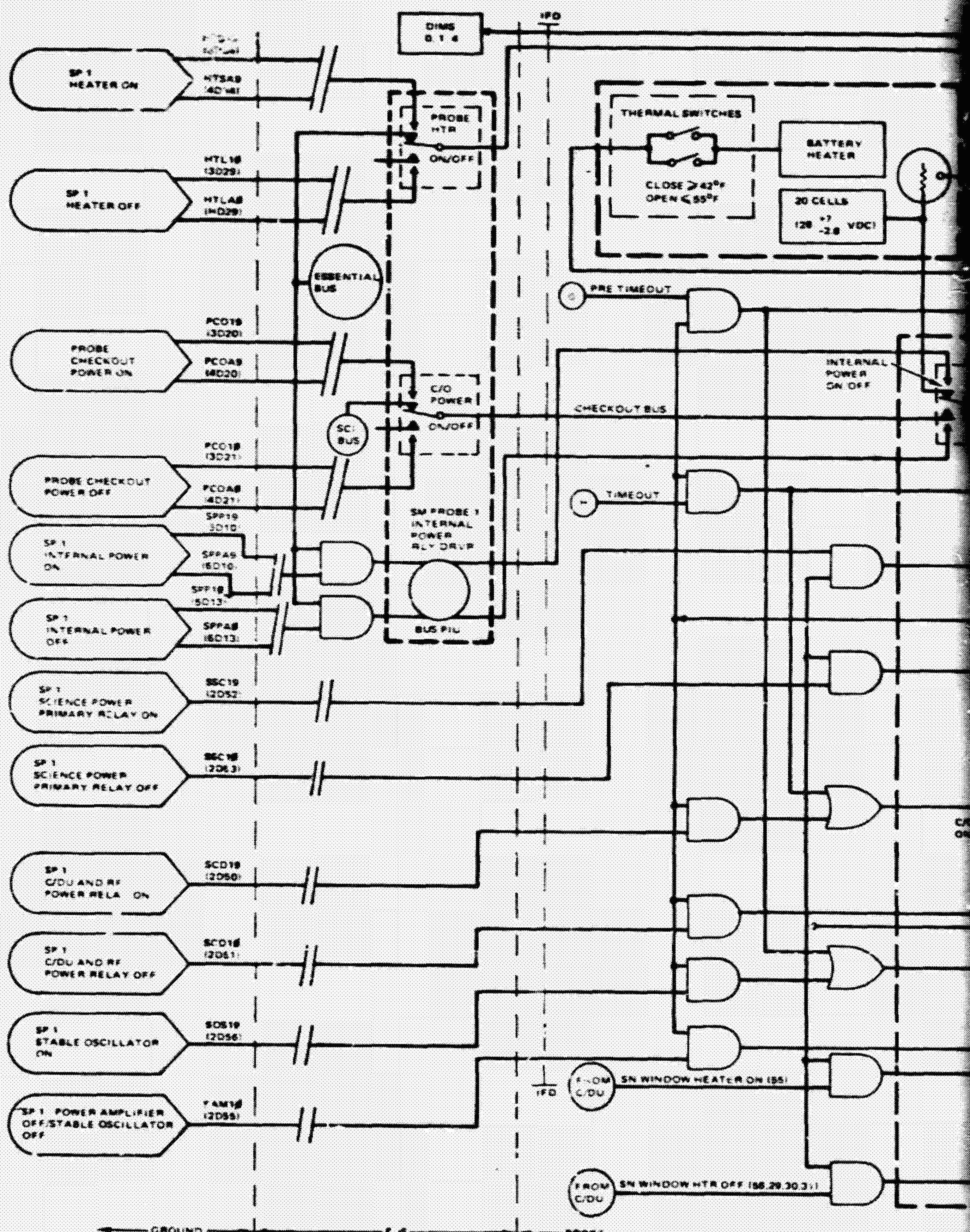
TICAL EXCEPT FOR NOMENCLATURE
TLY OFF POWER BUSES (B), (C), (D)
R CONVERSION IS ACCOMPLISHED

O SCIENTIFIC INSTRUMENTS

DATA BUS WHICH INCLUDES
TA FROM SAS AND SN

EPRESENT UPPER AND LOWER
INCLUDES DATA FROM SAS, SN.

LATCHING AND DO NOT CHANGE
R IS TURNED OFF
CURRENTS, AND TEMPERATURES
CE VALUES



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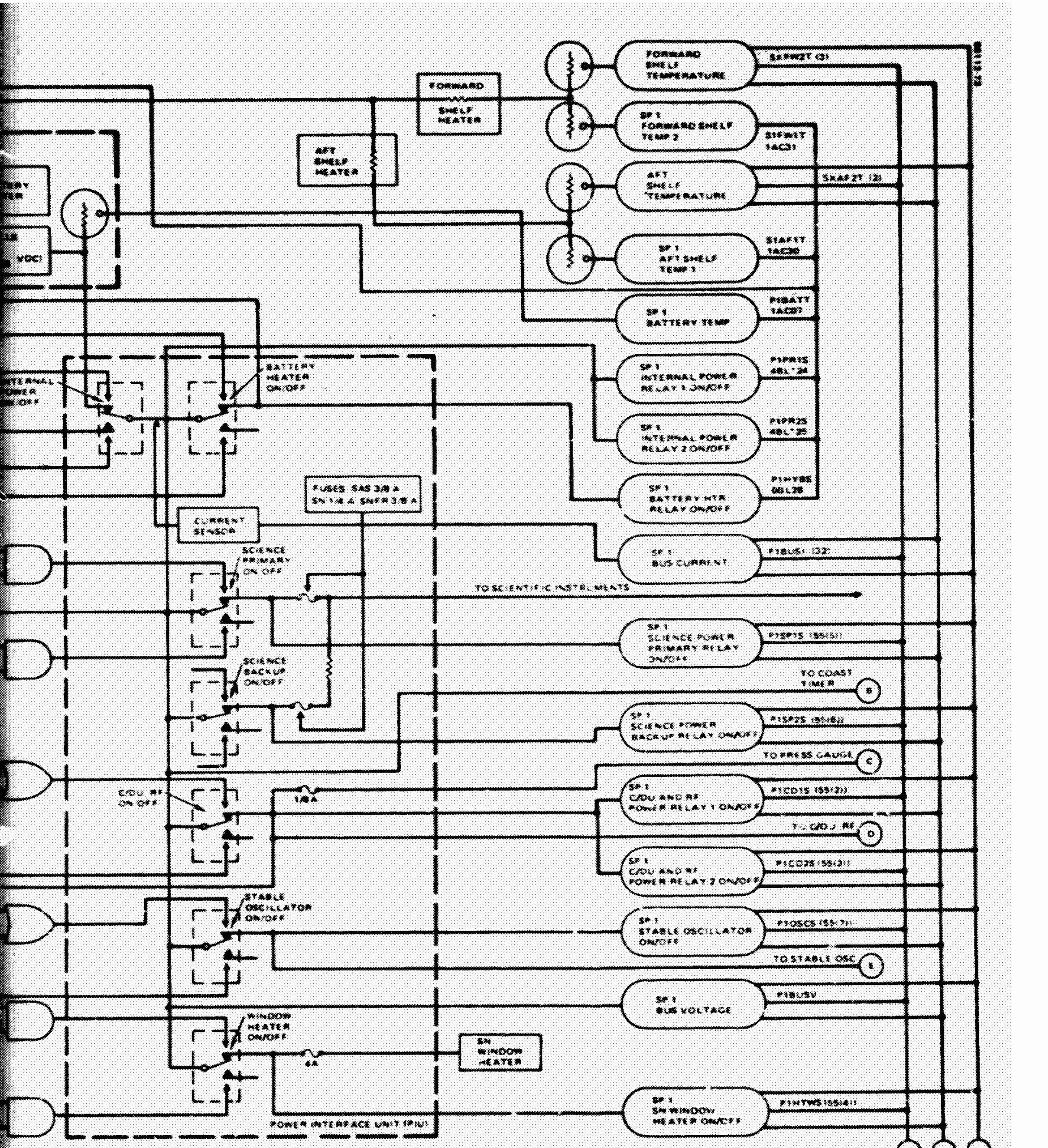

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FIGURE 5.2.2.2 1. SMALL PROBE 1 COMMAND AND TELEMETR

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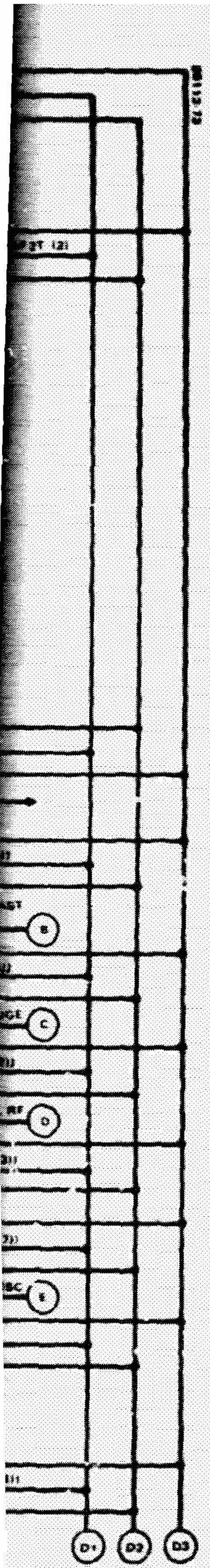

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COMMAND AND TELEMETRY LOGIC FLOW DIAGRAM

SHEET NO. C-33/C-34